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A HANDBOOK

OF

MEDICAL ELECTRICITY

A HANDBOOK

OF

MEDICAL ELECTRICITY

BY

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MEDICAL OFFICER FOR ELECTRICAL TREATMENT TO THE HOSPITAL FOR SICK
CHILDREN, GREAT ORMOND STREET.

WITH SIXTY-FOUR ILLUSTRATIONS

BIBLIOTHECA BODLEIANA

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160. e. 111.

PREFACE.

I SHOULD hesitate to add to the multitude of treatises upon medical electricity which are before the profession did I know of any which, avoiding contested points in electro-physiology and therapeutics, teach the busy practitioner not only when to use electricity, but *in explicit and full detail,* how ; and which in moderate bulk contain only what it is essential to master. For a book of this sort I believe there is a general want, and that want I have endeavoured to supply. I claim no originality. There will be found here no new ground opened out, but only an earnest endeavour to sift the wheat of our existing knowledge from the chaff, and to make the reader as much at home with his electrical as with his other medical instruments ; and further to lead him to estimate electricity at its fair and proved value in therapeutics, as an agent, not to be indiscriminately advocated as a panacea, nor, on the other hand, neglected by the inexperienced, but in appropriate cases to be regarded as one of the most powerful and serviceable weapons with which we can combat disease. A handbook such as this should seek to give the results of the best work; and in endeavouring to carry this conception into execution I have availed myself freely of the extended experience of the Electrical Room of the National Hospital for the Paralysed and Epileptic, and have carefully consulted the standard authorities, especially Duchenne's unrivalled and exhaustive treatise on "Localized Electrization." For much of the anatomical detail in indirect electrization I am indebted to Ziemssen's "Die Electricität in der Medizin;" and of the illustrations some are original, and others are taken from Duchenne.

I have throughout endeavoured to keep constantly in view the practitioner rather than the theorist, especially in those points of detail which are of importance in order to secure the successful application of electricity, and to insure (a not insignificant matter in this respect) the comfort of the patient.

The instruments described are those which for some years I have made use of as well in private as in hospital practice, and they are equally adapted for either.*

H. T.

70, Guilford Street, Russell Square,
January 27*th*, 1873.

---

* By permission of the Board of Management, and through the courtesy of the physicians, the Electrical Room of the National Hospital for the Paralysed and Epileptic, Queen-square, Bloomsbury, and the treatment carried out there, are open to the inspection of medical practitioners on the ordinary days of the physicians' attendance.

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A HANDBOOK

OF

MEDICAL ELECTRICITY.

CHAPTER I.

MEDICAL ELECTRICITY AND ELECTRO-MEDICAL INSTRUMENTS.

Preliminary Remarks.

THE almost complete absence in the medical schools of the great hospitals of opportunities for an adequate study of electro-therapeutics, the importance of the subject, and the wide-spread attention that it is awakening throughout the profession, have determined me to sketch as briefly as is consistent with clearness the present position of the science and practice of medical electricity, and especially of its practice.

I need hardly recall to mind, that until quite recently, to venture to speak of electricity as a curative power was pretty certain to result in the speaker being branded as little better than a quack; and even now, although this universal scepticism

Preliminary Remarks.

has disappeared, ninety-nine out of every hundred medical men content themselves with the theoretical belief that in certain cases electricity may do good, without themselves using it; but I hope that before long it will be as common to see an electrical instrument on the consulting-room table as a stethoscope or an ophthalmoscope. Indeed, I think that nothing but the want of information as to the choice and management of instruments can explain the little headway that the *practice* of electricity has made with the mass of the profession—too much occupied in their daily work to spare time to study its uses in the hands of the very few physicians in this country who have given attention to the subject.

I assume on the part of the reader an acquaintance with the elementary facts of electricity, such as may be gathered from any handbook upon the Elements of Natural Philosophy. It will be no part of my object to discuss these facts, except incidentally with strict reference to their application to medicine.

In the first place I propose to describe the instruments which experience has proved to be reliable and not inordinately expensive, and how to keep them in good working order (a point of no little importance); and then, in full detail, how to use them. Afterwards I shall very briefly discuss their diagnostic and therapeutic application, and quote either from my own experience, or that of others, a few illustrative cases, referring for further examples to the many and voluminous writings of the German and French electro-therapeutists.

NOMENCLATURE.

Firstly, a word or two on nomenclature. **Nomenclature.**

Throughout this Handbook the following terms will be used:—

ELECTRIZATION.—The generic word for the application of electricity in therapeutics, and never to be made use of in any special or limited sense.

FRANKLINISM : FRANKLINIZATION.—*Friction or Static Electricity.*—The oldest known variety, the electricity of glass and amber, that with which the name of Franklin will always be associated.

VOLTAISM : VOLTAIZATION.—*Voltaic, Galvanic, Dynamic, Contact or Current Electricity, the Constant Current, Galvanism.*[*]—The electricity of chemical action, that of Volta and Galvani.

FARADISM : FARADIZATION.—*The Induced Current, Electro-magnetism, the Interrupted Current.*[†]—The currents of momentary duration discovered by Faraday to be generated or induced in a coil of copper wire by the action upon it, under certain conditions, of a permanent magnet, or of a voltaic current.

---

[*] "*Galvanism,*" although commonly used, is improperly applied as a designation of Voltaic electricity.

[†] The word "*interrupted current*" is most improperly applied to these induced currents. Its use should be strictly limited to breaks or interruptions of a true voltaic current.

OF INSTRUMENTS.*

Instruments.

To describe the many varieties of instruments in the market would alone fill a large volume. I propose only to refer to those which after numerous trials have been finally adopted for use at the National Hospital for the Paralysed and Epileptic as the most reliable, efficient, and, wear and tear considered, the cheapest. There are doubtless many others good and serviceable, but I have felt that the reader will rather thank me for not fatiguing him with an account of them all; and for relieving him as much as may be from the trouble of selection.

FRANKLINISM.

Franklinism.

Franklinism is most conveniently generated by a Plate Machine (see fig. 1), in which the electricity arising from the friction of the rotating glass plate (B, fig. 1), against the upper and lower cushions, is collected by the two brass arms C, and distributed

---

* *The reader is strongly advised to satisfy himself that any instrument he may purchase is the manufacture of the original maker. Duchenne's instruments can only be obtained* PROPERLY MADE *from Charrière, of Paris; and Stöhrer's, if genuine, are stamped "Dr. E. Stöhrer, Dresden." Unless this rule is adhered to disappointment will result, and the therapeutic application will be unsatisfactory.*

Franklinism.

to the brass conductor, from which they branch out, and which is insulated by glass supports.

I should recommend a machine with a plate of

FIG. 1.

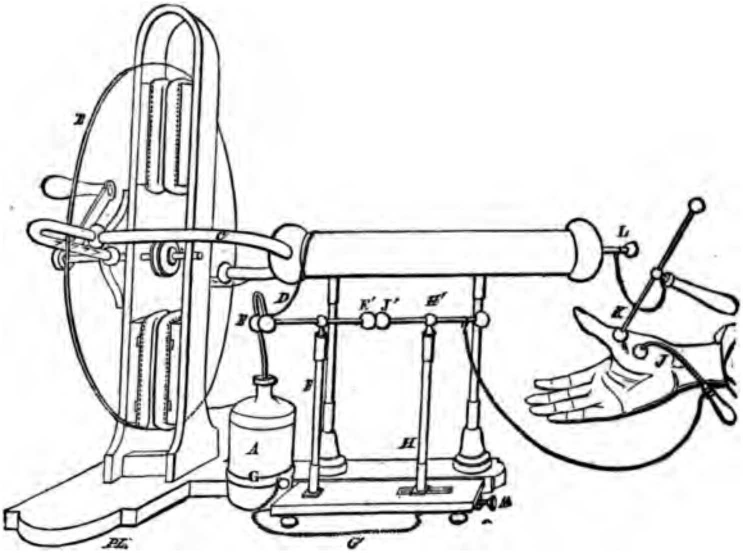


Plate Electrical Machine, and Electrometer.*

---

* B, the revolving glass disk; C, the arms leading to the prime conductor at whose extremity, L, is a brass chain connected with K, a metal excitor or discharger insulated by a glass handle; A, a Leyden jar with its interior coating communicating through the ball E, and chain D, with the prime conductor, and so with the excitor K, and also with the first branch E′, of the Electrometer. H′, its second branch, which by a rack movement, W, can be separated or approximated to its first, and which is connected by the chain G′ with the outer coating of the jar and also with the second excitor J. The two excitors, K and J, representing thus the charge of the outer and inner coating of the jar, can discharge it through any muscle. The intensity of the charge is regulated by the distance apart of the balls E′ J′.

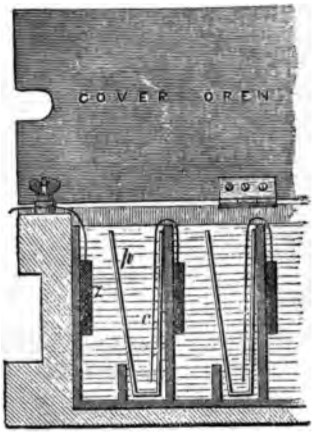
Franklinism. about two feet in diameter. The machine should be fixed upon a firm stand or table, that it may be quite steady during rotation. The one that I habitually use is firmly screwed to a heavy painted deal table. It was made by Elliott Brothers, 449, Strand, price 14*l.* 14*s.* There will also be needed a Leyden jar, two or three lengths of brass chain, or preferably of copper wire insulated by gutta percha; a couple of excitors insulated by glass handles (K and J, fig. 1); and a stool about four feet by two feet, with four glass balls or legs. A stool of this size admits of a chair being placed upon it, and it will be also useful for certain applications of voltaism, which will be mentioned later on. Four glass jars are also needed with which to insulate an ordinary couch. Care should be taken not to smear the cushions with too much amalgam, which had better be bought ready prepared. A piece about the size of a grape for each of the four cushions will be enough, and no more need be added for two or three months. The cushions should be screwed sufficiently tight to slightly "grip" the plate, and if it is found that notwithstanding having well warmed the flannel and rubbed all the glass of the apparatus, and especially the legs of the stool, that the instrument is not acting well, remove the cushions and warm them thoroughly. Always scrape off old amalgam before using new. It is impossible to be too careful that everything is warm, clean and dry.

VOLTAISM.

Voltaism. Requisites of a Voltaic Battery.

The essential requisite of a voltaic battery for medical purposes is that the current of electricity which it supplies should not only be *continuous* but *constant*—should not vary appreciably in power during the application. Any battery which does not fulfil these requirements should be unhesitatingly rejected.

Fig. 2.



Muirhead's Battery.

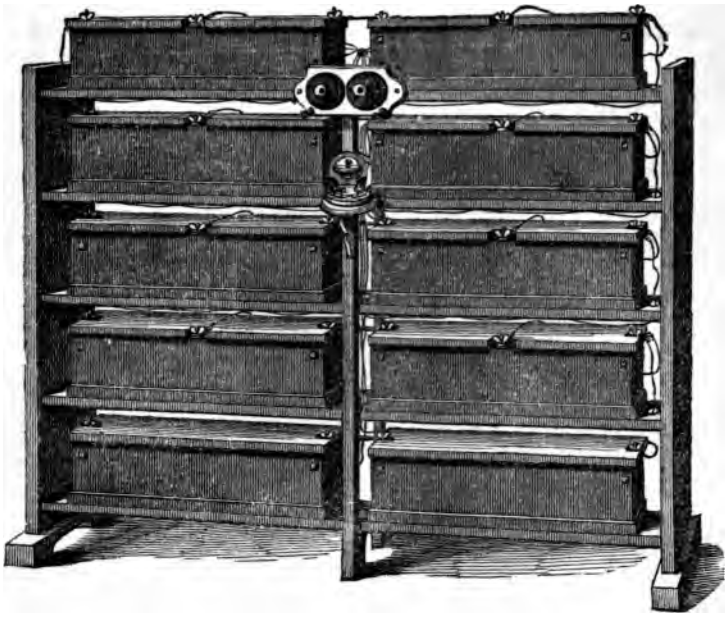
The Becker-Muirhead Battery.

The Becker-Muirhead Battery is a modification of Daniell's, and is that usually employed for telegraphic purposes. Its tension is low, but its action is very uniform. The elements consist of an un-

The Becker-Muirhead Battery.

amalgamated zinc plate (fig. 2, *z*), and of a thin copper plate, *c*. The copper plate is immersed in a solution of sulphate of copper contained in a porous cell, *h*; the zinc plate is immersed in water only, contained, with the porous cell and its contents, in a quadrangular porcelain vessel. The porcelain vessels are constructed in couples, each couple holding two pairs of elements, and five of these couples are packed in a strong oak box. The arrangement of

Fig. 3.



The Becker-Muirhead Battery as arranged at the National Hospital for the Paralysed and Epileptic.

The Becker-Muirhead Battery.

the battery adopted at the National Hospital, as least complex, is shown in fig. 3, in which ten boxes containing one hundred pairs of elements are placed upon a simple open stand. The pairs are grouped in sets of five, and the terminal wires of these sets are attached to buttons in rear of two revolving disks, numbered respectively from 5 to 45, and from 50 to 100. By turning the disks the operator, without detaching the conducting wires with which the excitors are connected with the instrument, can bring into play the current from as many sets of cells as he desires. When in daily use the cells require to be re-charged and the zincs cleaned every two months, and new zinc plates are needed about every three years. This battery was designed by Mr. Becker, of the firm of Messrs. Elliott Brothers, 449, Strand, and it is supplied by them.

Mr. Becker has added to it, as a means of ascertaining its state of action, and as a guide to the operator, an ingeniously constructed tangent galvanometer. The battery when freshly charged and all connexions cleaned is in its most effective state, but as the strength gradually diminishes it is essential for the medical practitioner to be able to ascertain at any given time the degree of diminution, so that he may determine the number of cells to be used in any given case. The terminals of the galvanometer coil are connected with a simple commutator so that the current may be made to traverse

The Becker-Muirhead Battery.

the galvanometer or not. When the battery is in perfect action it has been found that

5	cells give	45°	deflection	of the needle	of the galvanometer.
10	„	57°	„	„	„
20	„	67°	„	„	„
30	„	70°	„	„	„
50	„	71°	„	„	„
100	„	73°	„	„	„

Should five cells only give 22° deflection, the battery would be half its strength (if for the sake of illustration we take the angles for the expression of the strength instead of the tangents), and a higher number of cells should be placed in action, where before five were sufficient.

This battery has been in use at the National Hospital, and in my own private residence for several years. With ordinary watchfulness of its state of action, and care and regularity in re-charging and cleansing, it has proved a very effective and trustworthy instrument, and from the simplicity of its construction it can be cleaned, re-charged, and repaired with facility by an ordinarily intelligent artisan. Giving off no fumes or odours, it may be placed in any room without hesitation, never becoming offensive. In my own house the battery is placed in a closet on the area floor, and the conducting wires are brought into the consulting room and attached to the disks there. To clean and re-charge it, all that is necessary is to scrape the zinc plates, which become very foul, and to wash them, as well as

The Becker-Muirhead Battery.

the copper plates and porous cells, in cold water, to refill the porous cells with a saturated solution of sulphate of copper, and the porcelain vessels with fresh water. The porous cells, which are very cheap, occasionally become clogged, when it is better to replace them, for which purpose a few spare cells should be kept on hand. In very hot weather when evaporation is rapid, it may be well to add a little fresh water without dismounting the battery, but this is very seldom required. If residing in town it is better to contract with the maker to do the recharging, of which the cost is about a sovereign. The price of a 100-cell battery is 25*l.*—of a 50-cell battery, 15*l.* 15*s.*

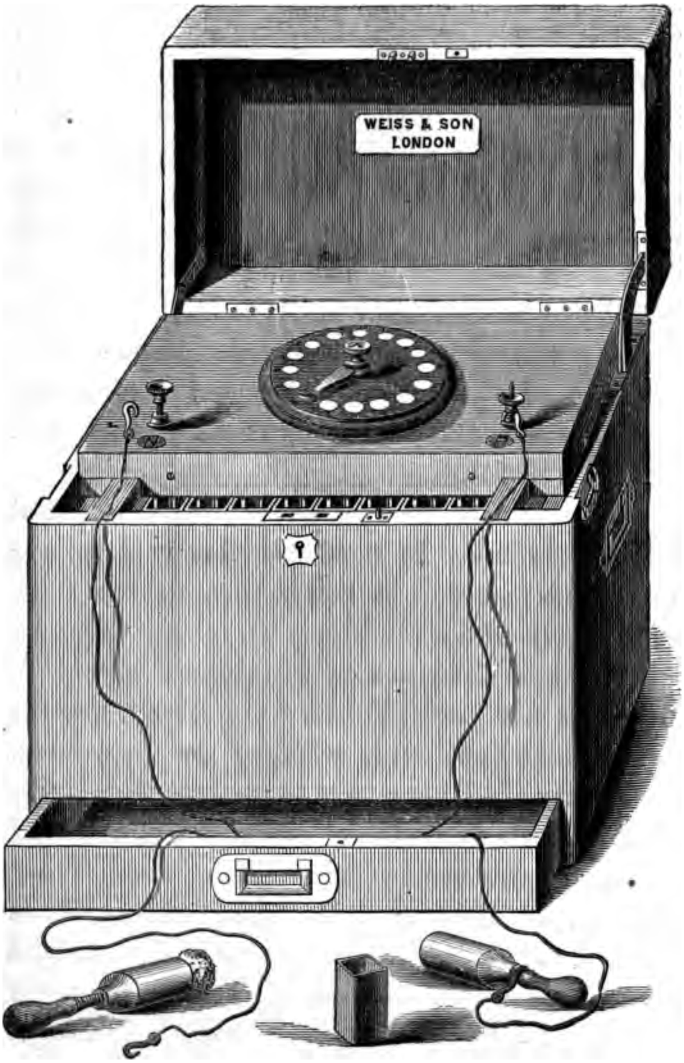
All connexions, binding screws, &c., of electrical instruments must be kept scrupulously clean, and to do this nothing is better than to rub them occasionally with a bit of very fine emery paper.

The single drawback to Muirhead's battery is that it is not portable. In every other respect it far surpasses any with which I am acquainted. Portability of a battery is of importance from facilitating the use of electricity as a means of diagnosis and in the treatment of cases not admitting of easy removal. M. Foveaux, of the firm of Messrs. Weiss and Co , 62, Strand, has designed and constructed a portable battery which is unsurpassed for efficiency of action, and compactness, consistent with efficiency.

Foveaux's Portable Battery.

Foveaux's Portable Battery is formed of pairs of

Fig. 4.

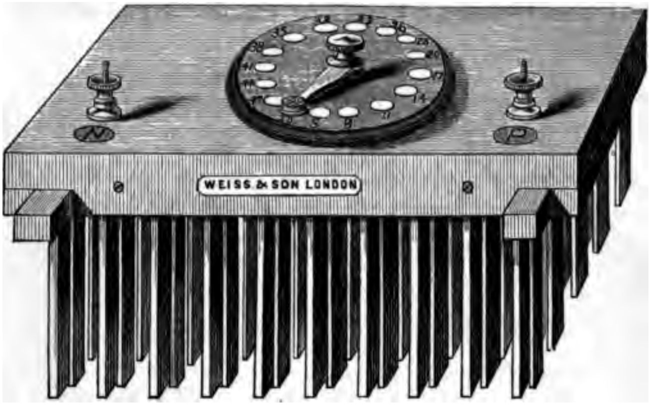


Foveaux's Portable Battery.

Foveaux's Portable Battery.

Smee's elements, packed into a handsome mahogany box, which measures in length 14 inches, in breadth, 7½ inches, and in height 10¼ inches (fig. 4). The cells containing the exciting fluid (diluted sulphuric acid), and which are constructed of porcelain, are attached to an ingeniously devised lifting arrangement. When the lid of the box is closed, and the battery is out of use, the cells and the contained exciting fluid are depressed beneath the elements, and the latter are no longer immersed. When the lid of the battery is raised to place the instrument in use, the cells are elevated and the elements immersed. By this arrangement the zinc is withdrawn from the destructive action of the acid when the apparatus is not in use, and the waste of the elements may be obviated to the greatest extent.

FIG. 5.

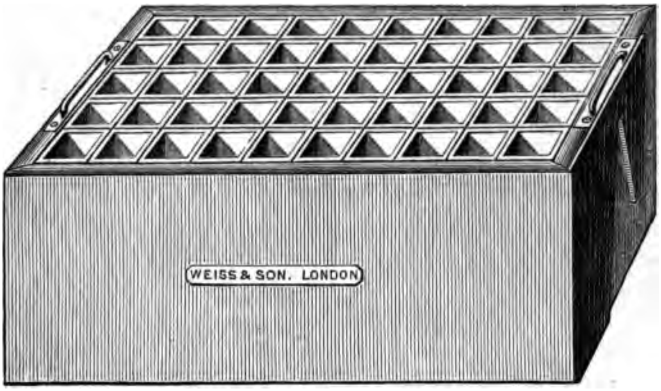


The Elements of Foveaux's Battery.

Foveaux's Portable Battery.

It requires, in constant daily use, to be charged about once in two months, by pouring into each cell a measured portion of diluted sulphuric acid (one part of strong acid to twenty-nine of water). A measure holding the requisite amount of acid is supplied with the instrument. To charge it the plates can be lifted out of the cells *en masse*, as shown in fig. 5, without any trouble in dismounting them. The elements being lifted out, the arrangement of the cells is seen in fig. 6. By means of a dial plate with a moveable needle, the current is graduated without detaching the conducting wires. The battery is mounted in sizes varying from twenty to sixty cells, and in price from 6*l.* to 15*l.* 15*s.* The more generally useful sizes contain thirty and sixty elements. I have used Foveaux's

Fig. 6.



The Cells of Foveaux's Battery.

battery chiefly in cases in which the interrupted voltaic current has been required to be used for diagnostic purposes. It is an exquisitely made instrument, and fully supplies a long felt want.

Foveaux's Portable Battery.

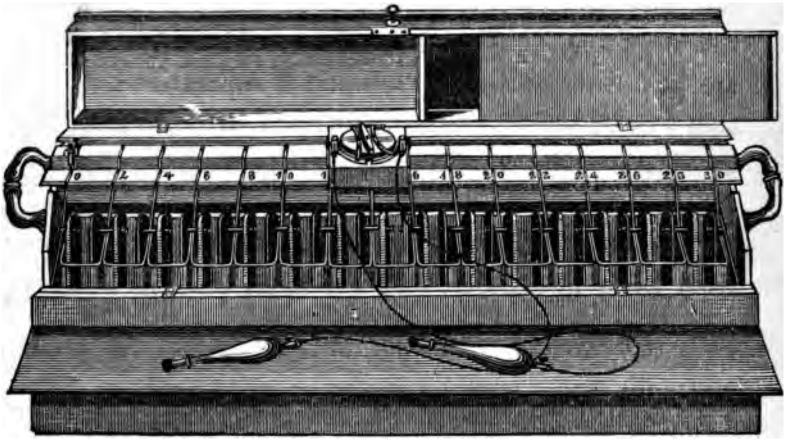
Stöhrer's Battery.

Stöhrer's Battery with Lifting Apparatus.—Stöhrer of Dresden has constructed a very excellent battery for medical purposes. The elements, consisting of carbon and zinc, are attached in pairs to a wooden rail, and project into glass vessels, which serve for the reception of diluted sulphuric acid, and which are so arranged in the completed apparatus, that they can be moved vertically up and down, and fixed in either position. By this arrangement the acid can be brought into contact with the zinc and carbon, or by shutting down the cells be excluded from them altogether. In the latter case the acid will only fill the lower third of the glass, and it is hardly possible that it can be spilt. Should, however, such an accident be apt to occur, a small stopper of caoutchouc at the left side of the base must be pulled out, and the instrument slightly inclined, that the acid may run out. The conducting cords are attached, as shown in figs. 7 and 8, to a simple and easily adjusted slide running in a groove upon the bar that supports the elements, and at its lower surface being in metallic connexion with them. By the movement of the slide any desired number of cells can be brought into operation; and on its upper surface is an ingeniously devised commutator, by

Stöhrer's Battery.

turning which to the right or left, the current admits of being reversed without removal of the conductors. The bar is marked from left to right with cyphers corresponding with the number of the elements, and their points of attachment, and it is of importance that the *centre* of the slide should be placed in a line with this attachment, as shown in fig. 7, in which fourteen, and in fig. 8, in which ten cells are in use. If this rule is neglected, rapid decomposition with development of gas, weakening of the current and general fouling of the instrument will result. In frequent use, re-amalgamation of the zincs will be required about once in six months, or whenever during use effervescence of the acid is perceived.

Fig. 7.

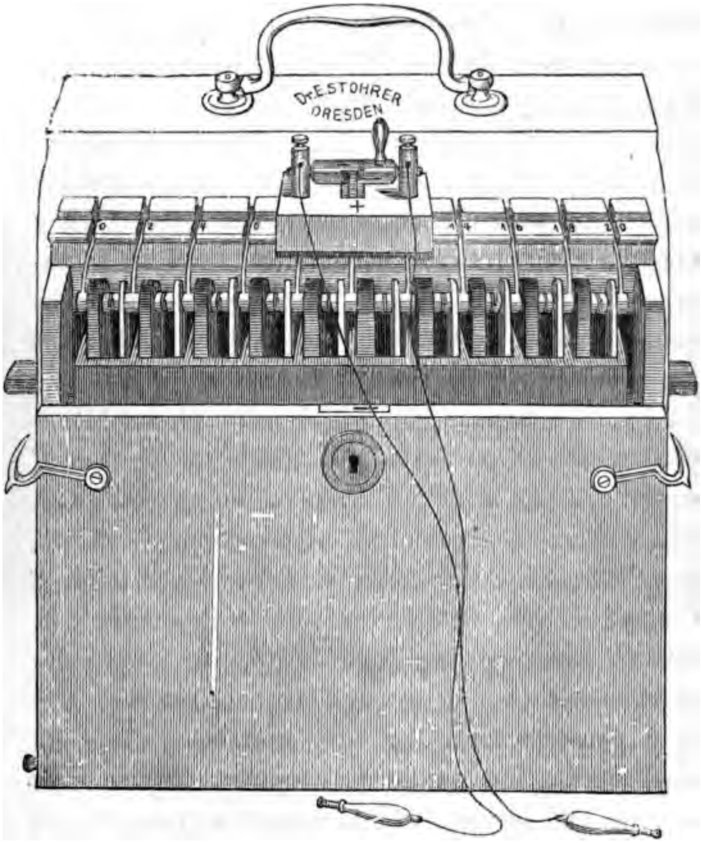


Stöhrer's Battery for Hospital use.

Stöhrer's Battery.

To re-amalgamate the zincs allow each plate to remain for about a minute in diluted sulphuric acid (one part of strong acid to seven parts of water) for which purpose a common tumbler answers well. Hold the plate over a second empty tumbler, and pour upon it about a teaspoonful of quicksilver.

Fig. 8.



Stöhrer's Portable Battery.

Stöhrer's Battery.

Rub the quicksilver well over the plate with a piece of sponge until it is quite bright; replace the plate for a moment in the acid, and notice if any bubbles of gas are evolved; if so, the amalgamation is imperfect, and more quicksilver will be required. If no gas is generated, rinse the plate for a moment in tepid water, and stand it aside to dry. At the same time the carbons should be soaked for about five minutes in tepid water (not hot), to dissolve the zinc salts with which they become encrusted. They may be also scrubbed with an old nail or tooth-brush. Clean all metallic connexions with emery paper, and do not screw the carbons and zincs together again until they have been allowed to dry for twelve hours. Charge each cell with a solution of one part of strong sulphuric acid to nineteen of water, and put in each a pinch (about as much as a pinch of snuff) of sulphate of mercury, which will greatly contribute to preserve the amalgamation of the zincs. Dr. Stöhrer constructs this battery in several sizes, varying from thirteen to forty pairs of elements (fig. 7), adapted for hospital use; and in a portable form (fig. 8) of essentially the same construction, but smaller and lighter. It is a most efficient and serviceable instrument, and equal to all the requirements of electro-therapeutics. Its price is from 6*l.* to 15*l.* 15*s.*

Pulvermacher's Chain Battery.

Pulvermacher's Chain Batteries.—As before stated, the fundamental requisite of a voltaic current for

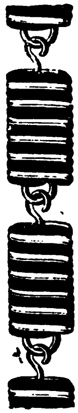
Pulvermacher's Chain Battery.

therapeutic application is its constancy. To obtain this property and at the same time a cheap and portable instrument, has been for years the effort of manufacturers. The most ingenious arrangement of the largest number of elements in the smallest space is to be found in Pulvermacher's chains. But in action they are *inconstant.* Steeped in vinegar they yield currents of high tension, but their action rapidly declines, and they become much weakened in a very short time. They may in the absence of a better instrument be occasionally of use for purposes of diagnosis, employed with electrodes in the same way as other batteries; but for therapeutical applications they are unsuitable, and worn upon the body as advocated by the inventor they exercise little or no benefit, except perhaps in some cases where they appear to act from their electrocutaneous excitation as counter-irritants. I am led to make these remarks and to describe these forms of battery from the very numerous letters of inquiry that I receive regarding them. The principle of their formation is that of the combination of a great number of elements, from 300 to 400, having but small surface. The original and best known forms of the chains are shown in figs. 9 and 10. The elements of which the chains are now constructed are formed of a cylinder of copper plate perforated with longitudinal openings, and within this cylinder is a cylinder of zinc without perforation. The zinc is

Pulvermacher's Chain Battery.

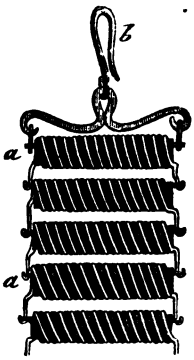
separated from immediate contact with the copper by a few stout threads. An unbroken link which forms part of the copper cylinder serves as the means for joining the several segments. This construction permits the withdrawal and renewal of the zinc when necessary.

Fig. 9.



Pulvermacher's Galvanic Chain.

Fig. 10.



Another form of Pulvermacher's Galvanic chain.

Faradism.

Requisites of a Faradic Instrument.

The essential requisites for a faradic instrument are: 1. The possession of a *primary* and *secondary* coil, constructed after certain proportions of thickness and length of wire.* 2. A sufficient range of power. 3. An exact means of graduation. 4. Constant readiness for action, and capability of being placed out of action without trouble and loss of time.

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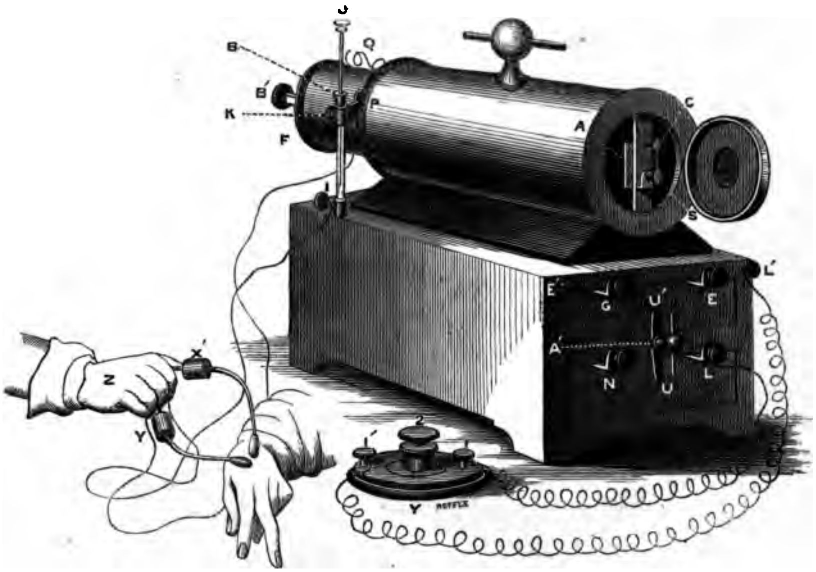
* The distinction between the primary and secondary coil *therapeutically*, is mainly a question of the greater tension of the current of the secondary coil, enabling its current to penetrate easily several thicknesses of muscle.

Duchenne's large Volta-faradic apparatus.—In this instrument the two coils forming the systems of induction are composed of two copper wires differing in diameter and length, and covered with silk.

Duchenne's large Volta-faradic Instrument.

Fig. 11.



Duchenne's large Volta-Faradic Instrument.

The thicker and shorter of the two wires is rolled around a bundle of soft iron wire so as to form a coil (the *primary* coil). The ends of this wire terminate upon two small plates of platinum at the level of the knobs E, L, fig. 11, which are the positive

Duchenne's large Volta-faradic Instrument.

and negative poles of the battery enclosed in the drawers U and U′. The finer and longer wire is rolled round the thicker and shorter coil and forms the *secondary* coil. Its ends terminate at the two springs of the commutator of the coils (E, fig. 14). This commutator is for the purpose of transmitting rapidly and alternately the current either of the primary or secondary coil to the conductors attached to the knobs P and Q, (fig. 11), according as the needle (F, fig. 14) is turned to the right or left, as is shown on a plate situated above the needle. The battery which works the instrument is composed of three pairs of elements contained in the drawers U and U′, two pairs in the upper and one in the lower. Each pair consists of a carbon plate (*c c′*, fig. 12) fixed to a cell of hard caoutchouc, and of a zinc plate, Z Z′, of the same surface as the carbon and separated from it by a cloth diaphragm. The platinum wires which form the carbon contacts are arranged as in the smaller instrument (fig. 17, page 30), while the zinc contacts differ in each of the pairs:—1. In the lower drawer (U, fig. 11) a strip of

FIG. 12.

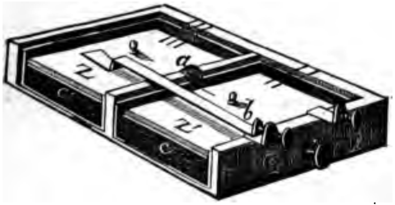
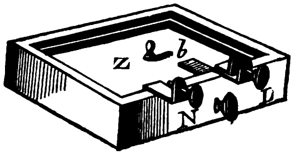


FIG. 13.



Duchenne's large Volta-faradic Instrument.

iron, (*b*, fig. 13), riveted and soldered to the zinc, z, is bent upwards at a right angle at its anterior extremity, in such a way that, when the drawer is closed, the iron comes in contact with a small plate of platinum fixed in the front of the apparatus on a level with the knob, L. 2. In the further compartment of the upper drawer, the zinc (z, fig. 12), is also prolonged by a strip of iron, *b*. This strip is also bent upwards at a right angle at its anterior extremity, and when the drawer is closed can be brought in contact with another small plate of platinum fixed in front of the apparatus on a level with the knob, G. 3. Lastly the zinc (z′, fig. 12), of the pair in the front compartment of the upper drawer rests on a platinum wire which winds over the posterior wall of the cell, and comes in contact with a double spring, *a*, fixed to the partition of the drawer, which spring in the further compartment rests by a platinized surface upon the carbon, C′. The left-side drawer is absent in the figure, in order to display the arrangement of the parts forming the two pairs. The graduator (B, fig. 11) is a cylinder of copper, which surrounds the coils, and which has a scale marked upon its upper part. The knob, B′, fixed to its extremity, is a handle by which it can be drawn out or pushed back.

The moderator is a glass tube (F, fig. 11), terminating below in a metallic base, to which is attached a knob, I, and above is a collar, K, from

Duchenne's large Volta-faradic Instrument.

which proceeds a hook, which serves to connect the moderator with one of the knobs, P, which receive the conducting wires to the electrodes, and in which the poles of the coils terminate. In the collar is a small opening traversed by the stem of the moderator, J. The tube is filled with water.

The trembler is composed of a piece of soft iron (A, fig. 11), and of a platinized screw, S, against which the soft iron is pressed by a small spring. The pedal (Y, fig. 11) is to allow slow intermissions to be produced with the foot, an arrangement which leaves the hands of the operator free, either to hold the conductors or to graduate the currents.

Duchenne's large Uncovered Instrument.

Duchenne's large Uncovered Apparatus (fig. 14) differs from that just described in the following respects:—1. It has no external covering, so that the arrangement of the coil A, and the movement of the cylinder B over it, may be seen. 2. It possesses two graduator tubes; one, B, which acts upon the secondary coil; and another, C, upon the primary. 3. Its core of soft iron, D, is moveable, and may be withdrawn so that we may study the influence of the tubes B and C, independently of temporary magnetization. 4. Besides the commutator of the coils, E, it possesses a commutator of the poles, H, forming part of its structure, and by which the directions of the currents may be rapidly changed without displacing the conductors. 5. The trembler is so constructed that the rapidity of the intermissions can be progressively increased from four or eight in the second, to an almost incalculable number in the same period of time.

Duchenne's large Uncovered Instrument.

Fig. 14.

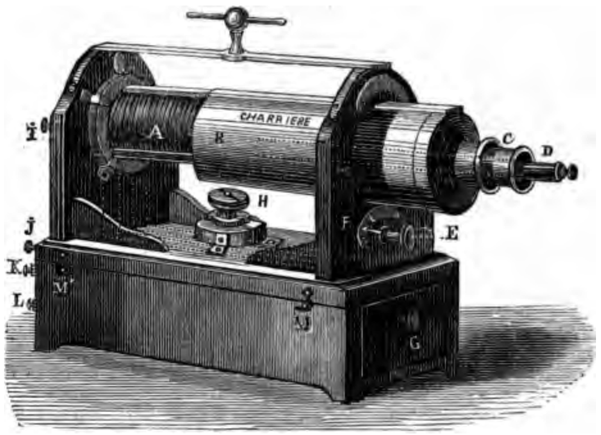


Fig. 15.

Fig. 14.—Large uncovered Volta-Faradic Instrument. Fig. 15.—Bundle of soft iron wire.

To charge the battery water must be poured over the carbon until it is well saturated; then spread over its surface bisulphate of mercury in quantity sufficient to form a thin layer. Place upon this layer the cloth diaphragm well wetted, and over this the plate of amalgamated zinc, which then comes in contact with the platinum wires. Thus prepared, the elements are placed in their compartments, which are distinguished by numbers marked on the sides of the caoutchouc cells. Lastly, the drawers

Duchenne's large Uncovered Instrument.

(U U′, fig. 11) must be shut, and the button, A′, turned in such a manner that its bar assumes a vertical direction and prevents them from opening. The communications of the elements of the battery with each other, and with the circuit of the primary coil, are then established. The knob, L′, must be turned from left to right, and the knobs, E, G, L, N, screwed into contact with their platinum connexions.

If it be desired to obtain rapid intermissions of the trembler (A, fig. 11), turn from right to left the knob C, which fixes the moveable plate, and then turn from left to right the buttons E, G, L, N, so as to bring them into contact with the pieces of platinum to which they correspond. When this is done the plate oscillates rapidly between the screw S and the temporary magnet of the central coil. If intermissions, more or less separated from one another are desired, the arrangement is made as before, except that the button, C, is turned from left to right so as to render the plate, A, of the trembler immovable, and the button, L, from left to right so as to separate it from its platinum connexion. Then connect with this button one of the conductors fixed to one of the knobs, I, of the pedal rheotome, Y, and the other conductor from the knob, I′ of the rheotome, is attached to the button, L′. It is then only necessary to govern with the foot the spring contact, 2, of the pedal rheotome, in order to make and break contact at pleasure. It is therefore perfectly easy to obtain intermissions separated by any desired interval.

Duchenne's large Uncovered Instrument.

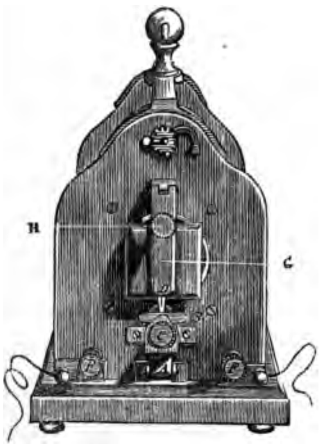
When the graduator, B, is entirely contained within the instrument, the currents are at the minimum of intensity; and, in order to increase them, it is only necessary to draw out this tube. The instrument being in action the conductors must be fixed to the knobs, P and Q, to which is brought the current of either the primary or secondary coil by turning to the right or the left the needle of the commutator. If it is proposed to measure infinitely weak doses the upper part, K, of the moderator, F, must be connected with one of the knobs, P or Q, and one of the conductors with the lower part of the moderator, I. Then the more the stem, J, of the moderator is drawn up, the greater will be the thickness of the water traversed by the current, and the more the latter will be weakened. The current may then be divided and measured by the tube graduator, B. In the intervals between faradization, the current is interrupted by turning back the screw, E, so as to preserve the force of the battery. At the same time plates of hard caoutchouc must be placed between the cloth and the zinc, care being taken to wipe the latter if the instrument will not be required again for some hours. A battery thus charged will last for two or three weeks, and may be used for several hours a day, without any other care than to renew the moisture of the cloth, and

Duchenne's large Uncovered Instrument.

to move a little every day, before use, the paste of mercury upon the carbon. It is also desirable to maintain the platinum connexions in a state of cleanliness. When the mercurial paste is quite decomposed (its colour originally yellow will then be green), the carbon must be washed, and the battery charged with fresh bisulphate as before.

Duchenne also adapts to his uncovered instrument a special trembler, whose beats may be quickened or retarded at pleasure. It is shown in fig. 16, a front view of this instrument. One of the extremities of the wire of the primary coil communicates with the knob, E, the other with the screw, C. The moveable piece of copper, A, which is pressed back by a spring placed in front of it against the screw C, communicates with the knob, F. As soon as the knobs, E and F, are placed in communication with the poles of a battery, the current passes through the wire of the primary coil, and magnetizes its core of soft iron, which attracts the moveable piece of soft iron, G. This draws with

Fig. 16.



Front view of the instrument shown in fig. 14.

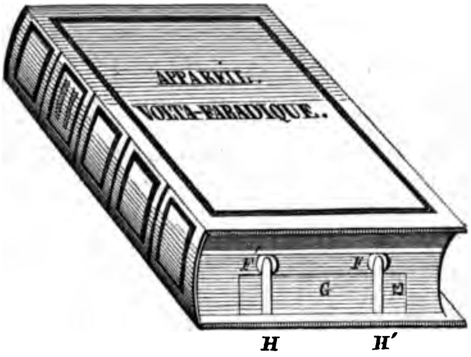
Duchenne's large Uncovered Instrument.

it the piece of copper, A, which was resting against the screw, C. A solution of continuity is produced, demagnetizing the core, and causing the return of A to C. The same order of events continues, the current being re-established. When the screw, C, is tightened, the spring which presses the piece, A, against it, is sufficiently tense to cause the intermissions to occur without vibrations; but when the spring is relaxed by loosening the screw, each beat or intermission is followed by a vibration such that its slowest action (four intermissions per second) produces muscular contractions that are painful, although infrequent. These slow intermissions are sometimes highly useful. In the trembler the point of the screw is platinized and comes in contact with a plate also platinized, and soldered to the piece which beats against it, so that perfect contact is as little as possible interfered with by oxydation. In time, however, the platinum burnt by the electric spark does undergo oxydation; and the oxyde deposited on its surface checks the passage of the current and weakens the power of the instrument, the play of the trembler being either hindered or altogether stopped. This fault has been remedied by increasing the thickness of the piece of platinum, and by making it moveable, so that when after working some hours a day for many months, it becomes oxydized, it may be shifted a little to the left or right, and a new place brought into use. Clean also the point of the screw from time to time, by rubbing it with a piece of fine emery paper, to remove the oxyde.

Duchenne's small Volta-faradic Instrument.

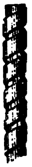
Duchenne's small Volta-faradic Instrument, is a reduction of the instrument just described. It has the form of a flat oblong box (fig. 17). When it is open, as in fig. 19, it is seen to be divided into two parts. To the right is placed the induction instrument, properly so called. To the left is the battery in the lower compartment, A, and the electrodes and their conductors are in the upper compartment B. The induction apparatus is composed of the two superposed coils, the wires of which are of different length and diameter, and of a core formed by a broad band of soft iron, rolled into a helix, as in figure 18, so that it can be

Fig. 17.



Duchenne's small Volta-Faradic Instrument (closed).

Fig. 18.



Soft Iron.

Duchenne's small Volta-faradic Instrument.

placed in the centre of the coils. There is also a commutator, C (all the foregoing portions are concealed in the compartment to the right). There is a graduator tube, D, a trembler, E, and a rheotome, L, for slow intermissions. A pair of elements with

FIG. 20.

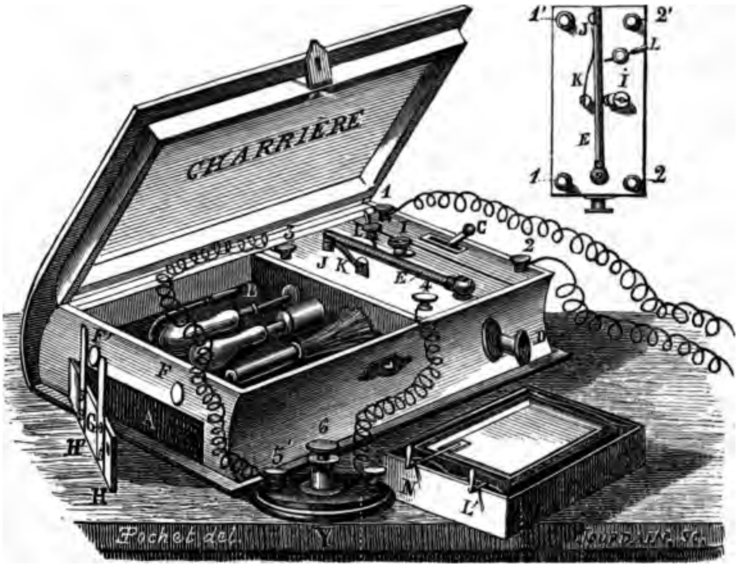


FIG. 19. FIG. 21. FIG. 22.

Fig. 19.—Duchenne's small Volta-faradic Instrument. (Opened.)
Fig. 20.—Details of the cover of the compartment to the right.
Fig. 21.—Pedal.
Fig. 22.—Pair of elements with bisulphide of mercury.

bisulphate of mercury is introduced into the compartment A. Then if the door, G, of this compartment be closed as in fig. 17, the small platinized plate L′ (fig. 22) which communicates with the carbon contained in the caoutchouc cell, comes in

Duchenne's small Volta-faradic Instrument.

contact with the spring, H, which rests against the platinized termination, F, of one of the extremities (poles) of the primary coil, while the zinc (N, fig. 22), is brought into communication with the other extremity (pole) of the primary coil, by the spring, H′. If it is wished that the intermissions should be made slowly, the knob L (fig. 20), must be turned till the line traced upon it is directed transversely. If rapid intermissions are desired, the button, I, must be turned from right to left until the bar, E, pushed forward by a platinized eccentric fixed to the button, is sufficiently near to the temporary magnet, J, which is in contact with the soft iron in the centre of the coil. The approximation is sufficient when the noise of the trembler can be heard. The movements of the trembler must be carefully regulated. Slow intermissions may also be produced with the pedal rheotome, Y (already described with the large instrument). For this purpose its conducting wires must be attached to the knobs 3 and 4 (fig. 19), and then after having turned the button, L, from left to right, until the bar, E, is in contact with the magnet, J (in this position the battery current is interrupted), the intermissions are to be made with the foot in the manner already described. (By pressing on the knob, 6, fig. 21, the battery current is completed). The electrode knobs, 1 and 2, receive the currents of each coil, and to them are fixed the conducting wires. To these knobs the

Duchenne's small Volta-faradic Instrument.

current either of the primary or secondary coil can be brought by pushing to the left or to the right, as far as it will go, the stem of the commutator of the coils, C. The figures engraved upon the small plate of copper traversed by this stem, point out the side towards which the stem should be pushed in order to bring one or other of the currents to the knobs 1 and 2. The graduation is effected by the tube, D, as in the other instruments. In the intervals between the applications the battery current is interrupted by pushing back the stem of the rheotome, L, until the bar, E, is in contact with the soft iron, J.

The power of this small instrument is very considerable, regard being had to the small size of its coil. This is not only due to the excellent proportions of length and diameter of its wires, and to good manufacture, but also, and chiefly, to the powerful magnetization of its band of soft iron rolled into a helix, which thus offers a considerable extent of surface.

Duchenne's Magneto-faradic Instrument.

Duchenne's Magneto-faradic Instrument.—This consists of a magnet; of an armature set in movement by a peculiar mechanism; of a regulator of the armature that is at once a moderator of the currents and a magnetic tensor; of two coils of copper wire of unequal length and thickness; of a rheotome; of a regulator of the intermissions; of a

Duchenne's Magneto-faradic Instrument.

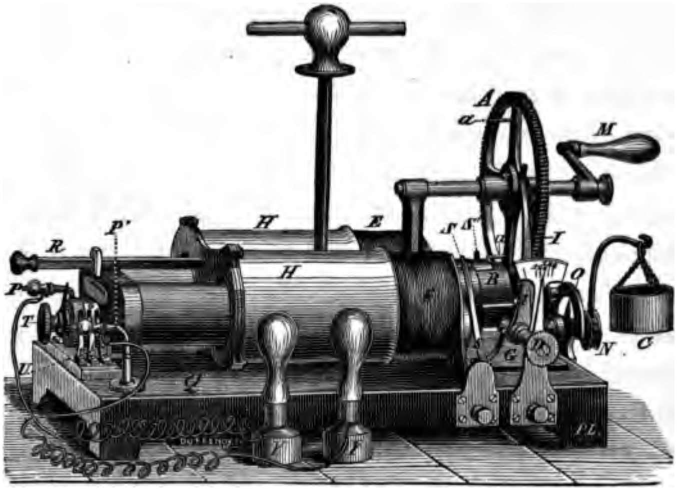
graduator of the currents; and of a commutator of the poles (fig. 23).

The magnet is formed of two parallel cylindrical branches, connected together at one of their extremities by a transverse bar of soft iron. The armature which, by its movement of rotation, produces the intermissions of the magnetic current, is traversed in its centre by a horizontal axis terminated at its extremities by a very hard steel point, received in steel sockets, which are screwed into two copper mounts. These mounts are firmly fixed to a square moveable plate of copper (G, fig. 23), which rests on the base of the apparatus. Between these two mounts, and at their superior extremity, is fitted a large wheel, A, the axis of which traverses on one side the anterior mount in which it rotates, while the other extremity terminates in a point, and is received in a piece fixed to the posterior mount. The handle, M, which puts the large wheel in motion, can be removed at pleasure. The circumference of this large wheel is divided into sixty-four teeth, which set in action a small wheel of eight teeth, fixed upon the axis of the armature in such a manner that at every revolution of the great wheel the armature turns eight times upon its axis, and consequently produces thirty-two intermissions of the current of induction. As it is possible to make the larger wheel revolve twice in a second, we may obtain sixty-four intermissions in that time. The

Duchenne's Magneto-faradic Instrument.

moveable plate, G, is brought near to, or removed from, the magnet by means of a strong screw, N, called the regulator of the armature. This screw turning in a nut fixed to the instrument, acts upon the base of one of the mounts which forms part of the plate, G, which it moves backwards and forwards. In order that the armature may exercise tension upon the magnet, the screw, N, is so turned that the needle is brought to the centre of the arc of a circle, O, which is called the indicator. The superposed coils are similar to those of the Volta-faradic instrument. The end of the one is soldered to the beginning of the other, while the other ends are brought—that of the thick wire to the springs, s,

FIG. 23.



Duchenne's Magneto-faradic Instrument.

Duchenne's Magneto-faradic Instrument.

and s′, which produce the intermissions on the reel, B; and that of the fine wire to the right side, U, of the commutator of the coils, T, which conducts the current of the primary coil to the knobs, P and P′, to which are attached the conductors of the rheophores. The spring, s′, gives origin to a conducting wire which proceeds to the left side of the commutator, T. The rheotome is composed of a small wooden reel, B, and of two springs, s and s′. The reel is fixed upon an axis of soft iron. One of the springs, s, in relation with one end of the central wire, rests upon a metallic ring fixed upon the reel. This ring is divided into four teeth, two of which are very short. The second spring, s′, which communicates with the other end of the central wire, is brought into contact with the four, or with the two teeth, by means of the regulating knob of the commutator (not shown in fig. 23), which is fixed to the right of the instrument, and which rotates from right to left, and *vice versâ*. The intermissions are thus regulated:—A piece of copper is fixed to the base of the instrument, to the left of the large wheel. It is traversed by a screw, D, to which is soldered a brass spring, I. By means of the screw, D, the spring, I, can be made to perform a to-and-fro movement, which brings it in contact sometimes with the pins *a*, upon the posterior face of the great wheel, A, and sometimes with the plate, G, which supports the latter. One of the extremities

Duchenne's Magneto-faradic Instrument.

of the inner, and one of the outer, wires of the coil communicate with this plate, G. The brass spring, I, is in relation by a copper wire with the left side, U, of the commutator, T. The currents are graduated by two tubes of copper, H H, which glide over the reels, and can be pulled out or pushed in by the stem, R. When pushed home, the cylinders cover the reels, and the currents are at their minimum of intensity, and at their maximum when the stem is drawn completely out. The commutator of the coils has the same construction as in the Volta-faradic instrument.

In order to put the instrument in action the regulator of the armature, N, must be turned from left to right until the soft iron no longer comes in contact with the magnet during its rotatory movement. If the employment of a rapid current is desired, the regulator of intermissions, D, must be turned from right to left until it reaches its point of arrest. If, on the contrary, slow intermissions are desired, the same indicator, D, must be turned in the opposite direction, and stopped when its needle points to the number of intermissions which it is desired to obtain for each revolution of the large wheel. The handle, turned from left to right, should always be moved very quietly, making perhaps two revolutions in a second. In order to graduate the currents, it is sufficient to remember that when the stem, R, is pushed home, the current is at its mini-

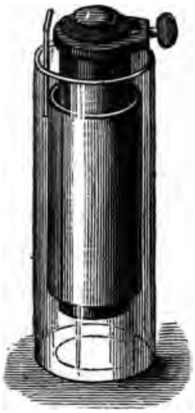
Duchenne's Magneto-faradic Instrument.

mum. If still more feeble doses are required, the armature must be moved further away from the magnet by turning the regulator, N, from left to right. The knob, T, of the commutator of the coils must be turned from right to left, when it is wished to bring the currents of the primary coil to the knobs, P and P′. On the contrary, the knob, T, is turned from left to right, to get the current of the secondary coil.

Stöhrer's Induction Instrument.

Stöhrer's Induction Instrument.—The battery of this instrument consists of carbon and zinc, without an earthenware cell. The carbon (fig. 24), hollow within, filled with sand, and closed by a glass stopper, serves for the reception of a concentrated solution of chromic acid in water. Of this solution 10 or 12 drops should be added whenever the battery is re-charged. The zinc surrounds the carbon, but is kept from contact by glass insulating buttons. These elements are placed in a circular glass cell, which serves for the reception of diluted sulphuric acid (one part acid to seven parts water). This cell is so arranged in the completed apparatus, that it can be moved vertically up and down, and can be fixed at any point. By this arrangement the acid can be

Fig. 24.

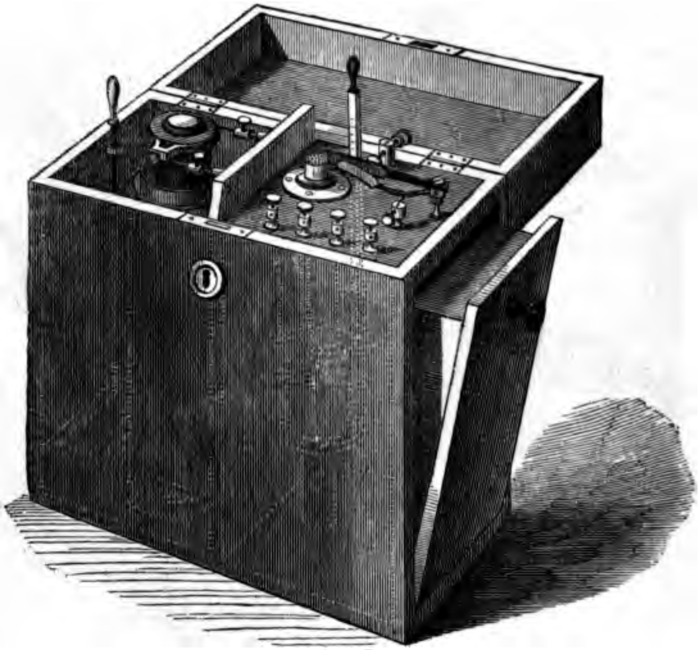


Stöhrer's Battery.

Stöhrer's Induction Instrument.

brought into contact with the whole, or with part of the zinc and carbon, or by shutting down the glass, can be excluded from them altogether. In the latter case, the acid will only fill the lower third of the glass. The advantages arising from being able to remove the elements at once, and without difficulty, from the exciting fluid, and from the facility with which they may be brought into action, are obvious.

FIG. 25.



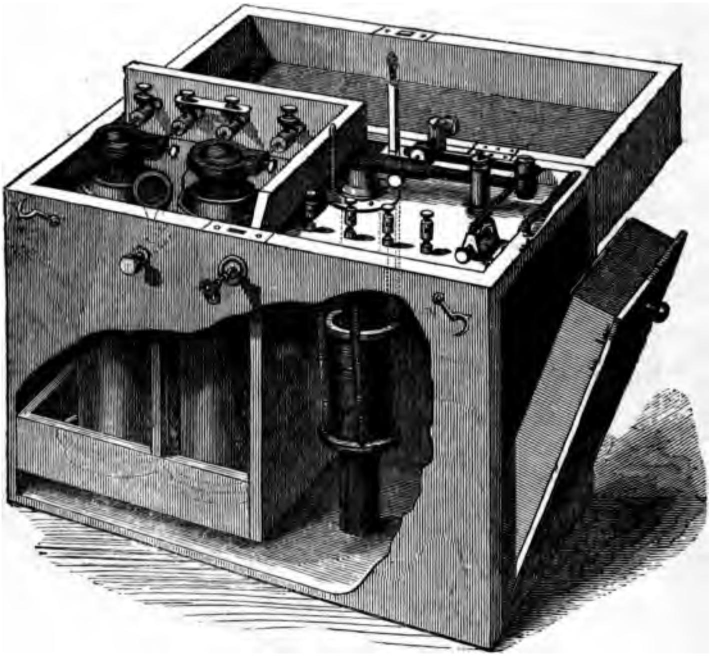
Stöhrer's smaller Induction Instrument.

Stöhrer constructs a smaller (fig. 25), and a

Stöhrer's Induction Instrument.

larger (fig. 26) instrument. The battery of the former is constituted by a single cell; of the latter, by two cells, which may, however, be arranged either as two pairs, or as a single pair of elements. Both possess a primary and a secondary coil, the currents of each of which can be made use of separately; and in both the currents have a definite direction, positive electricity being set free at one terminal, and negative at the other, of each of the coils. The terminal from which the positive current

Fig. 26.



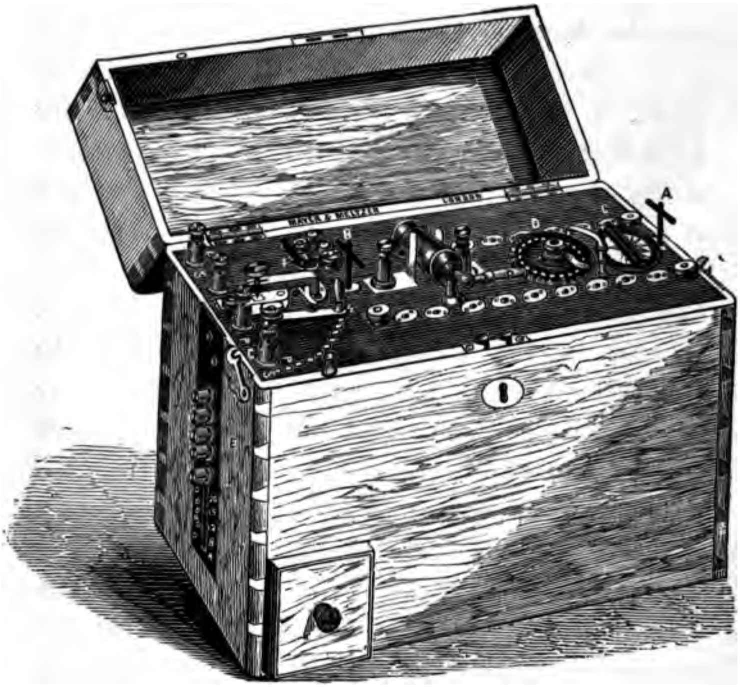
Stöhrer's larger Induction Instrument.

Stöhrer's Induction Instrument.

proceeds may be ascertained easily by the decomposition of iodide of potassium. The larger instrument differs from the smaller in having a much greater range of power, more thorough means of graduating the currents, and a more elaborate arrangement of the interrupting hammer. With practice, however, the force and rate of interruption of the smaller instrument may be regulated with much nicety. To neither instrument is a water graduator attached; but if needed for any special nicety of application, one can readily be added, and it would be best carried loose in the drawer for accessories, to be attached only when required. Graduation of the strength of the currents is effected by the arrangement of the coils. The primary coil is fixed upon a pedestal; the secondary is moveable, and is brought into and placed out of action by being lifted over or thrust away from the primary. The degree of action in the secondary coil is proportionate to the extent to which it is brought under the influence of the primary. The action of the primary coil is regulated in the smaller instrument by the extent to which it is masked by the secondary coil—the latter acting upon it as a metallic sheath would do. In the larger apparatus a special copper sheath is provided for the graduation of the current of the primary coil. It is to be regretted that a similar arrangement has not been adopted in the smaller instrument.

Duchenne's large volta-faradic apparatus is unquestionably the most perfect for medical purposes. Stöhrer's apparatus is the best adapted for the ordinary exigencies of active practice.

FIG. 27.*



Meyer and Meltzer's combined Voltaic and Faradic Battery.

* A, B. Handles to lift out the elements *en masse*. D. Graduator. E. Levers for raising the cells. F. Interrupting hammer. G. Galvanometer. P. Commutator of the poles. S, S. Terminations of the primary and secondary coils.

Meyer and Meltzer's Combination Battery.

Meyer and Meltzer's Combined Voltaic and Faradic Battery.—Messrs. Meyer and Meltzer, of Great

Portland Street, have recently constructed an instrument (fig. 27), containing twenty zinco-carbon cells, and in addition a primary and secondary induction coil. Tested for a week at the National Hospital for the Paralysed and Epileptic, it gave very fair results, and may be recommended both for purposes of diagnosis and treatment to medical practitioners who only occasionally make use of electricity. For anything like continuous work, it is however better to use the separate instruments already described. The prices of this ingenious apparatus are 12*l.* 12*s.* and 10*l.* 10*s.*

The Accessories of the Apparatus.

Accessories of the Apparatus.

The Conducting Wires.

The first necessary accessory is a conducting cord or wire between the poles of the instrument and the sponge holders, electrodes, or as they are generally called rheophores (current carriers). I have had endless trouble with conducting cords, which are always liable to get out of order and cause interruptions in the current. I strongly advise that nothing should be used but very thin copper wire coated with gutta percha in the same way as that known as "telegraph wire." This is perfectly insulated, sufficiently pliable for all practical purposes, it is inexpensive, it does not kink, it will fit any sort of rheophore, and if the end breaks, all that is necessary is to scrape off with a pocket knife the coating for about a couple of inches from the broken

Accessories of the Apparatus.

end. For use when the rheophores remain immovable during the whole time of the application, the ordinary telegraph wire is more convenient, and from its much greater diameter will wear much longer, but it is not sufficiently flexible for other purposes. The other accessories will be described with their special uses in the next chapter.

CHAPTER II.

THE APPLICATION OF ELECTRICITY.

The Application of Electricity.

THE scientific electro-therapeutic application of electricity is the growth of the last thirty years. Prior to this date the difficulty of obtaining apparatus adapted for the purpose and the consequent inconvenience of the whole proceeding, seems to have stopped all enquirers at the very threshold. To Duchenne (who has been aptly called the "father of electro-therapeutics") may fairly be ascribed the birth of medical electricity as a branch of therapeutics, and his writings undoubtedly impelled to its study some of the most painstaking physicians, especially in Germany. Before Duchenne no one had attempted any local application of electricity that could be properly so called. The only effort towards this end had been that of Sarlandière in 1825, who conceived the ingenious idea of using acupuncture in order to direct and limit the power of electricity within certain nerves or muscles. The pain of this application, especially when a large number of needles were inserted, and many other disadvantages, precluded it from being adopted in practice.

But it appears to have suggested to Duchenne that in some way it might be possible to arrest electricity in the skin without stimulating the subjacent organs; or on the contrary, to cause it to penetrate the skin without influencing it, and concentrate its power on the deeply-seated muscles or nerves. The result of his experiments was entirely successful, and we owe to him the fundamental principles of all methods of localized electrization. He applied to the dry skin the dry metallic conductors of an induction instrument in action. Sparks and crackling were produced, but no physiological phenomena. *The electricity did not penetrate the skin.* He replaced the dry conductors by well-moistened sponges. The current produced neither sparks nor crackling, but very variable phenomena of contractility or sensibility, *according as it acted upon a muscle, a nerve, or an osseous surface.** Duchenne distinguished between "direct muscular electrization," the production of contraction by placing the rheophores on the muscle itself, and "indirect muscular electrization," in which contraction is produced by exciting the nerve trunk or branches. By the German school these have been also termed "intra-muscular" and "extra-muscular" electrization; but before entering upon this part of the subject, it will be convenient to consider the more general methods of application, beginning with Franklinization.

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* See Duchenne (de Boulogne) "On Localized Electrization and its applications to Pathology and Therapeutics." (English edition.) Part I. pp. 38–44. London: Hardwicke.

FRANKLINIZATION.

Franklinization.

To administer Franklinism, insulate the patient by letting him stand upon a glass-legged stool, sit upon a chair placed on a platform with glass supports, or recline upon a couch the four legs of which are insulated by being inserted into large glass jars. Then connect him by a brass chain held in his hand with the conductor of a friction machine in action, and thus make him as it were a part of it. The accumulated electricity passes to him, and he becomes in common with the conductor *charged*. If the air were perfectly dry he would continue in this charged condition, but owing to its contained moisture the electricity rapidly leaves him, and to maintain the charge it is necessary that the plate should be kept in constant rotation. Indeed the escape of electricty is so rapid that to get good action you must have a fire in the room and before use well rub the plate, the insulating supports, the legs of the stool, and all the glass parts of the apparatus with a warm and dry piece of flannel. This is of importance, and however dry the day, should as a rule never be neglected. The patient charged from the prime conductor, is said to be taking an *electro-positive bath ;* but if he

(a) Electro-positive Bath.

Franklinization.

be connected by the chain with the cushions of the machine, instead of with its conductor, he would be charged not with positive but with negative electricity and—be taking an *electro-negative bath.* The whole surface of the body becomes charged with electricity, which escapes from all points of the skin. If it is desired to localize somewhat this escape along the course of certain nerve branches, or otherwise, but to avoid shock, a brush may be slowly passed by the operator almost, but not quite, in contact with the skin. A series of rapid and successive reunions of the electricity with each bristle of the brush takes place, generating a current of cold air perceptible to the patient. I habitually use for this application an ordinary clothes-brush. If, while in connexion with the prime conductor any object, (the knuckles will do,) is brought sufficiently near to him for his contained electricity to overcome the resistance of the intervening stratum of air, he is "*discharged*" with a spark. This is *Franklinization by sparks,* and is accompanied by a certain slight amount of "shock." If it be desired to render this shock painful, electricity of a degree of tension only to be obtained from a sufficiently charged Leyden jar or jars must be made use of, and this may be rendered so powerful that the whole limb, or even the whole body is as it were struck by lightning. This is *Franklinization by the Leyden jar.* To apply

(*b*) Electro-negative Bath.

(*c*) Franklinization by Sparks.

(*d*) Franklinization by the Leyden Jar.

Franklinization.

(d) Franklinization by the Leyden Jar.

this form of Franklinization, well warm the inside and outside of the jar, and place it with its knob, communicating by the rod with its inner coating, sufficiently near to the conductor of the machine in action to draw sparks from it. Also connect by a hook and brass chain, or preferably a length of insulated wire, the same knob with one of the excitors, such as K (fig. 1, p. 5) insulated by a glass handle, and the outer coating of the jar by a second wire, looped round it, with a second insulated excitor, J; then have the machine rotated until the number of sparks required have passed into the jar, which is discharged by applying the extremities of the two excitors to the two points of the body through which it is desired that the electricity should pass. In fig. 1 the charge is being directed through the muscles of the ball of the thumb. This is the least complex way, but if it be desired to measure the charge carefully, and avoid too powerful a shock, Lane's electrometer (see fig. 1), should be employed, putting one of its horizontal branches in communication with the interior coating, and the other with the exterior, and separating the balls at their other ends more or less widely, according to the shock desired. Arranged in this manner, if through inadvertence the jar is overcharged, the two electricities will re-unite between the two knobs as soon as they acquire sufficient tension to overcome the resistance of the

Franklinization.

intervening air—a resistance that is in direct proportion to the distance between the knobs.

If necessary, two or more jars may be combined by connecting their outer and inner coatings, but it is very rarely required to use more than one, provided it be of adequate size, say of about forty ounces.

VOLTAIZATION.

Voltaization.

(a) Constant.

Voltaization is administered under two forms, the "*constant*" and the "*interrupted*" voltaic current. In the "constant" current the conductors are maintained immovable upon the skin; or the feet or hands, as the case may be, are immersed in tepid salt water, with which the conducting wires of the battery are in contact, and the current is allowed to pass during the time required. The tension of voltaic electricity is so low that salt is required to render the water a good conductor. In the "interrupted voltaic current" the current is INTERRUPTED by gliding over the skin one or both of the rheophores; or the feet or hands may be placed in salt water with one pole, and the other pole may alone be moveable. There is an application of *positive* voltaic electricity, originated by Dr. Radcliffe, the therapeutics of which will be discussed hereafter, in which the patient and the battery must both be insulated, in which the passage of the current must be quite constant, and in which a wire, which Dr. Radcliffe terms a "ground wire," must be carried

(b) Interrupted

Dr. Radcliffe's Positive Charge.

Dr. Radcliffe's Positive Charge.

from the negative pole of the battery, or from the negative rheophore, to the earth. This wire may conveniently be attached to a chandelier or gas-pipe, which always gives a direct metallic conduction to the ground. With careful insulation, the negative electricity passes away by this wire, and while the current circulates the patient continues "*charged*" with positive electricity—a condition analogous to the electro-positive bath described under Franklinization. A sheet of gutta percha about four feet square by half an inch thick, will answer admirably to insulate the patient and the accessories.

LOCALIZED VOLTAIZATION AND LOCALIZED FARADIZATION.

Localized Electrization.

Localized voltaization and localized faradization require the same operative procedures, and in describing them I shall make use of the term electrization.

Direct Muscular Electrization.

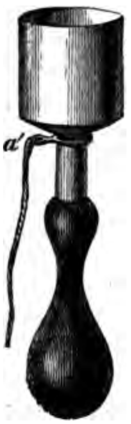
Direct Muscular Electrization.

In direct muscular electrization the muscular tissue is directly excited by placing well moistened rheophores on points of the skin corresponding to the muscle it is desired to act upon. For the muscles of the trunk which have a large surface, it is most convenient to use well moistened sponges contained in cylinders, or metallic disks covered with wet leather and having conveniently shaped handles.

Rheophores.

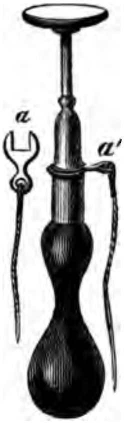
Fig. 28 is one of Duchenne's sponge-holders. All others that I have seen are much too long in the cylinder, and the reader in ordering would do well to give the dimensions, about 1½ by 1⅛ inches, and to see that the handles are hollowed out as in the figure. It is astonishing how difficult it is to get an instrument maker to do this, and to have it properly done makes a material difference in the ease with which they can be used, lying comfortably between the fingers, as in fig. 30, which shows the most convenient method of holding two rheophores in the same hand. Fig. 29 is a disk rheophore, a metallic button covered with washleather. This is by far the most generally

FIG. 28.



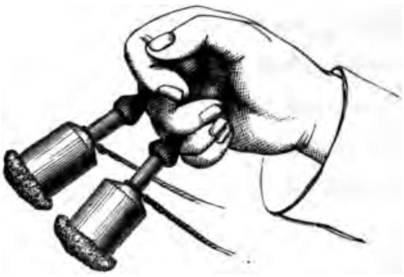
Sponge holder with insulating handle.

FIG. 29.



Metallic rheophore with disk.

FIG. 30.



Method of holding rheophores.

Different kinds of Rheophores.

useful rheophore ; and by using the edge it may be made to answer in the majority of cases for fig. 32. It also has the advantage over the sponge of allowing firm pressure to be made without the inconvenience of water being squeezed out. *a*, fig. 29, shows the usual method of connecting the conducting cord with the rheophore, which is seen *in situ*, received into the screw socket of the rheophore in *a*′. The cord is very apt to get frayed where it passes through the eyelet hole, which spoils it at

FIG. 32.

FIG. 31.

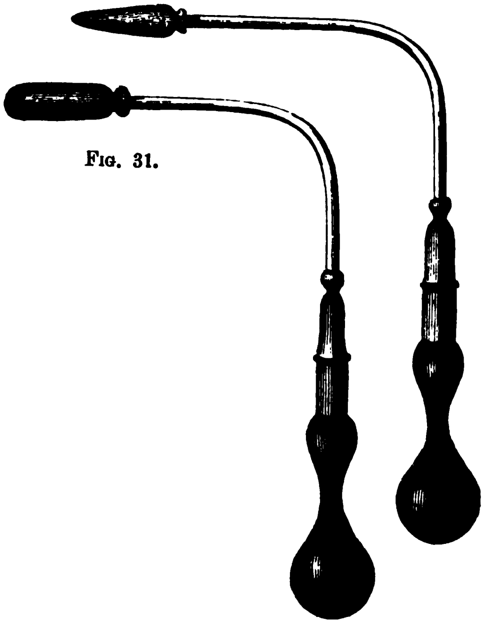
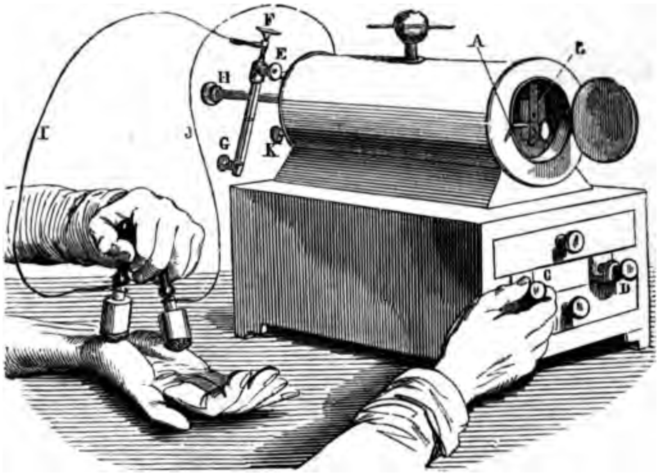


Fig. 31. Olivary metallic rheophore. Fig. 32. Conical metallic rheophore.

Different kinds of Rheophores.

once. That the wire which has been previously recommended is not open to this objection is not the least of its advantages. Figs. 31 and 32 are other varieties of rheophore, fitted chiefly for application to very small muscles, such as the interossei, and some of those of the face. Fig. 33 shows Duchenne's method

Fig. 33.



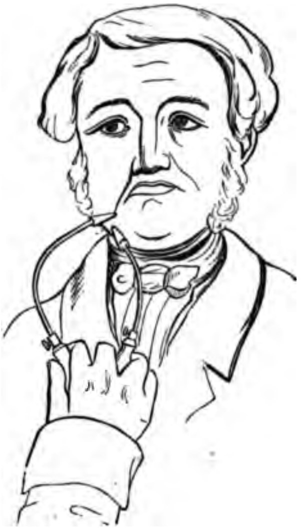
Method of holding the Sponge-holders in a single hand.

Method of holding Rheophores.

of holding two rheophores. The application is being made to the muscles of the hypothenar eminence with one hand, while the other hand is employed about the instrument. In fig. 34 the conical rheophores are in like manner applied to the face. As it is requisite to administer to a muscle a dose of electricity proportionate to its degree of excitability, the operator should whenever possible have one hand at liberty. In direct electrization the rheophores must always be applied over the fleshy body of the muscle and not over its tendons, and in order to electrize it completely *they should cover the whole of its surface, and when they are not large enough to do this, they must be applied in succession to all points of its surface. The thicker the substance of the muscle the more intense must be the current, because a weak current will only produce excitation of the superficial layers.* It is very necessary in practice not to lose sight for a moment of this fundamental axiom, which one is very apt to do, and so unequally to electrize the muscle; and it is a good rule to promenade, as it were, the two rheophores, held as in fig. 31 or fig. 33, in lines along and across the muscle or group of muscles; keeping them stationary on *every point of the muscle* for about thirty seconds, and letting the entire application vary from five to fifteen minutes, according to therapeutic requirements. In direct electrization with the interrupted voltaic current it is more usual

Rule to be observed in Direct Muscular Electrization.

FIG. 34.



Duchenne's method of holding conical rheophores.

to maintain one rheophore stationary, and to glide the other in lines from the first. As a rule the positive electrode is the stationary, and the negative the moveable one, but this order can be reversed if necessary.

INDIRECT MUSCULAR ELECTRIZATION.

Indirect Muscular Electrization.

When muscular contraction is produced by acting upon the special nerve trunk and branches instead of by placing the rheophores upon the muscle itself, the procedure is termed *indirect muscular electrization.* For its successful practice a detailed knowledge of anatomical relations is necessary, especially of the position of the muscles and of their nerves with regard to one another, to the sensitive nerves and to the surface of the body. It is common to find variations in the course of the nerves, and in the mode of their distribution among the muscles, so that the points most suitable for their excitation can only be pointed out approximately.

It is convenient to place a broad conductor, such as a sponge contained in a cylinder (fig. 28), upon some little sensitive part of the body, such as the sternum, and to apply a fine-pointed conductor, such as the conical rheophore (fig. 32) to the most superficial point of the nerve it is desired to act upon.

The Head.

The trunk of the facial nerve may be excited from the external auditory meatus by pressing a thin electrode against its lower wall. Energetic contractions will be produced in all the muscles that the nerve supplies. With less pain in thin persons it may be found immediately after it leaves the stylo-mastoid foramen. Press the rheophore strongly, just below the concha, between the mastoid and condyloid processes. The branches from the facial to the stylo-hyoid and digastric muscles may be excited in thin men by pressing the electrode deeply behind the condyloid process of the lower jaw. Their contraction is shown by movements of the os hyoides outwards, backwards, and upwards. In the parotid gland the single large branches of the facial are easily found, and produce contraction in definite groups of muscles corresponding to the ordinary divisions of the nerve; those branches which leave the parotid, and rest more or less closely on the bone, are easily excited, but not those that are imbedded in soft parts, especially the buccal branches. The frontal muscle may be thrown into contraction from beyond its own limits, since the branch of the facial by which it is supplied, before dividing for its final distribution, courses for some distance from the temple to the zygoma. The orbicularis palpebrarum may be excited either upon the zygoma or beyond it towards the parotid gland; close to the orbital margin the nerve commonly divides into a superior and inferior branch supplying the upper

The Facial Nerve.

Branches to Stylo-hyoid and Digastric.

Branch to Frontal Muscle.

Branch to Orbicularis Palpebrarum.

The Facial Nerve.

and lower halves of the muscle. Excitation of the trunk before it divides closes the eye firmly. In the neighbourhood of the eye it is necessary to be very circumspect with the strength of the current (especially the voltaic). Duchenne quotes a case of blindness caused by too powerful an application of electricity, but weak faradization may be applied without injury even upon the conjunctiva, although the application is very painful, and causes profuse lachrymation and sometimes conjunctivitis.

Branch to Zygomaticus.

The nerve of the zygomaticus major may be excited quite close to the origin of the muscle at the inferior and external edge of the zygoma, and the certain bony support afforded for the pressure of the electrode makes its excitation unusually certain—more so than that of any other facial muscle. By its contraction the angle of the mouth and the contiguous portion of the upper lip are drawn upwards and outwards, and the skin of the cheek is thrown into deep folds.

Branch to Orbicularis Oris.

The orbicularis oris: The twigs to this circular muscle enter it at four points, on each side of the face one for the upper and one for the lower lip, and to produce complete contraction, four electrodes would be required. The twigs must be isolated in close vicinity to the external border of the muscle.

The Buccinator.

The buccinator: Its nerves have a variable course, and are best sought at the inner margin of the masseter. The cheek becomes tightly contracted, and pressed upon the teeth. The masseter and temporal muscles, on account of the deep entrance of their motor nerves, can only be thrown into contraction by direct muscular excitation, since the belly of the muscle intervenes between the electrode and the entrance and course of the nerve. Of the nerves of the cavity of the mouth, those of the tongue are the most accessible. Excited on either side, the tongue becomes contracted and bowed towards that side. If when drawn upwards and backwards, its under surface is excited, it will be forcibly protruded. The velum can be only slightly distorted by lateral excitation, but its contraction and displacement backwards and upwards are easily produced by feeble currents.

Nerves of the Cavity of the Mouth.

The Neck.

Nerve of Willis.

The accessory nerve of Willis, external branch, may always be isolated with facility. After passing out behind the sterno-mastoid, and giving its branch to that muscle, its course is superficial to the trapezius. Above the origin of the branch to the sterno-mastoid, it may be reached without difficulty by pressing the electrode strongly into the middle of the belly of the upper half of that muscle; or if this does not succeed, by placing the electrode behind the belly of the muscle, and pressing it upwards and inwards. Simultaneous contraction of the sterno-mastoid and trapezius result; the cervical

Nerve of Willis.

spine is bowed, the lower jaw pushed forwards, and the head rotated so as to turn the face away from the side that is irritated; the shoulder is strongly elevated and drawn backwards and inwards. The sternomastoid alone, may be thrown into strong contraction by its branch from the accessorius. Direct the electrode a little below the point for the main trunk of the nerve. Irritation of the accessorius close to the margin of the trapezius will throw this muscle into isolated contraction with either elevation of the shoulder backwards and upwards, with drawing up of scapula, or depression of head backwards and outwards, or both movements, according as the head or scapula is fixed by antagonist muscles.

Hypoglossal Nerve.

The hypoglossal nerve is accessible close above the great cornu of the hyoid bone in front of the hyoglossus muscle. The usual result is elevation of the whole tongue against the hard palate, with simultaneous action of the hyoglossus, and other muscles.

Rhythmical Electrization of the Phrenic Nerves, and their accessories.

Electrization of Phrenic Nerves.

The phrenic nerve may be discovered at the outer margin of the sternomastoid, in front of the scalenus anticus, and above the omohyoid. It must not be sought too deeply, but the electrode must be pressed inwards against the outer margin of the sternomastoid. If the point of the electrode

Electrization of Phrenic Nerves.

be carried too high, it will encounter the fifth cervical nerve, which forms an acute angle with the phrenic. The electrode must not be carried above the middle of the sternomastoid, but kept near the omohyoid, the exact position of which is very easily found by faradization. The electrodes must be pressed in strongly, and in an oblique direction from without inwards. The proof that the phrenic is reached is afforded by rapid contraction of the diaphragm, arching forwards of the trunk, and forcible rushing of air through the glottis into the trachea, with a noise like the sobbing of a crying child. A powerful current is required, and its strength must be gradually increased until decided action of the diaphragm is obtained. The excitation, whether of one nerve or both, is unattended by danger, and generally produces no pain. In artificial respiration one electrode should be placed over the phrenic at the point where the omohyoid lies at the outer border of the sternomastoid, and the other upon the side of the thorax in the seventh intercostal space, and pressed in as deeply as possible towards the diaphragm. Faradization in this manner should be applied to the right and left sides alternately, and the circuit maintained unbroken for about the period of a deep inspiration. Or the two phrenics may be simultaneously excited. Take the disk rheophores (fig. 29), place them on both sides of the neck over the lower end of the scalenus anticus at the outer

Electrization of Phrenic Nerves.

margin of the sternomastoid, direct them somewhat inwards, and press firmly. We may in this way be certain not only to excite the phrenic nerves, but also, from the extent of bearing of the electrodes, to produce contraction of the inspiratory muscles supplied by nerves which traverse the path of the current, as well as directly to excite the scalenus anticus and sternomastoid.

The large electrodes are recommended for these reasons as well as for the greater ease with which we are enabled to hit the phrenics. It is also necessary that the head, shoulders, and arms of the patient should be fixed by assistants, in order that the auxiliary muscles of inspiration, especially the serratus anticus major, and the pectorals, should have fixed points from which they may energetically act upon the chest; and sometimes in order to control disturbing movements of the upper extremities, caused by accidental irritation of the motor twigs proceeding to them from the brachial plexus. The length of each excitation should be that of a quiet deep inspiration, that is, about three seconds. The expiration is best accomplished by an assistant, who makes strong and extensive pressure upon the abdomen in the direction from below upwards. It is necessary to make a pause after a number of excitations, and to observe whether spontaneous respiration will occur. The duration of such a pause must be governed by the character of the natural respira-

Electrization of Phrenic Nerves.

tory movements. Care must be taken to maintain the conductors in position and well pressed down.

The Brachial Plexus.

The motor nerves proceeding to the shoulder and thorax from the supra-clavicular portion of the brachial plexus may all be excited under favourable circumstances without the chief trunks of the plexus being involved. In all cases, exact anatomical knowledge, together with experience in faradization and in the use of fine electrodes, is necessary. The trunks of the supra-clavicular part of the brachial plexus are of no avail for the excitation of individual muscles, since the irritation of every single trunk causes the contraction of whole groups of muscles that have generally no harmony of action, but that receive nerve-fibrils from the same stem. Whenever the therapeutic value of indirect electrization does not depend upon the excitation of individual muscles, and when the unavoidably painful irritation of the sensitive fibres is unimportant, as, for example, in paralysis of the whole arm, electrization of the brachial plexus, on account of its superficial position, is especially adapted for an unpractised operator.

The Superior Extremity.

Axillary and Radial Nerves.

The axillary and radial nerves are both included in the posterior cord of the brachial plexus, so that by its excitation energetic contraction of the deltoid results, as well as of the muscles supplied by the radial nerve.

The Musculo-cutaneous Nerve.

The musculo-cutaneous nerve after its passage through the coraco-brachialis is found in the interval between that muscle and the biceps, or further outwards between the two heads of the biceps. Strong flexion of the forearm is the result of its excitation.

The Median Nerve.

The median nerve is accessible along the whole of the furrow by the inner side of the biceps, but with more certainty over the lower third of the humerus, after it has crossed to the inner side of the brachial artery, where it can be compressed against the bone. The result is pain in its sensitive branches distributed to the thumb, fingers, and palmar surface of the forearm, and contraction of the pronator teres, pronator quadratus, radialis internus, palmaris longus, flexor digitorum sublimis and profundus, as well as of the muscles of the ball of the thumb, and of the three first lumbricales. The effects, therefore, are strong pronation of the forearm, bending of the hand towards the radial side and flexion of the fingers with opposition to the thumb. In the forearm, an inch above the wrist, the nerve lies for some distance between the tendons of the palmaris longus and the radialis internus, almost quite superficial. Excitation here produces abduction of the thumb, with stronger opposition and slighter flexion of the first phalanges of the index and middle fingers.

The Ulnar Nerve.

The ulnar nerve may be excited along its whole course from the axilla to the elbow, although by

The Ulnar Nerve.

movement of the skin or of the nerves, an unintentional action of the median is easily produced. It is best to take the interval between the olecranon and the internal condyle, since here the nerve does not slip, but can be pressed firmly against the bone. Its excitation produces pain in the long palmar branch and its twigs to the fingers on the volar and dorsal sides of the hand, with contraction of the ulnaris internus, flexor digitorum profundus, palmaris brevis, muscles of the little finger, interossei, 4th lumbricales and abductor pollicis. After giving off its posterior branches, the nerve lies wholly superficial for a considerable distance above the wrist on the radial side of the tendon of the ulnaris internus; and it produces when excited here pain in the volar twigs and in the above-mentioned muscles of the hand. The hand is rendered concave, the thumb adducted, the little finger strongly flexed and opposed, and the remaining fingers moderately flexed at the metacarpo-phalangeal articulations.

The Radial Nerve.

The radial nerve is accessible at the posterior edge of the axillary cavity, but it is most superficial and more easily compressed on the outer edge of the humerus, where it passes round to the front. The spot is readily found by taking the middle point between the insertion of the deltoid and the external condyle, from this point somewhat outwards. Lower down, between the supinator longus

The Radial Nerve. and brachialis internus, it is more deeply placed but is still accessible. Its excitation above the external condyle causes painful sensations in the region of the superficial radial nerve down to the fingers on the dorsal surface, with contraction of the supinator brevis, ulnaris externus, radialis internus, extensor digitorum communis, extensor indicis, extensor minimi digiti, extensor pollicis longus and brevis, and abductor pollicis. It consequently produces supination of the forearm with complete extension of the hand and thumb, and extension of the first phalanges of the fingers.

The Trunk.

Internal Intercostal Nerve. Excitation of a single internal intercostal muscle may be effected by means of a thin electrode pressed against the lower margin of a rib, close to the insertion of a digitation of the serratus magnus. During quiet respiration we may thus produce a contraction of the muscle from the place of irritation to the junction of the rib with its cartilage, and thereby a strong lifting of the rib below, and in both of them it may be plainly seen and felt.

Nerves to Abdominal Muscles. The abdominal muscles can only be brought into partial contraction by one electrode, since they are supplied by several nerves. The rectus abdominis receives as many nerves as it has fleshy bellies. These nerves enter the muscle at its outer margin, and are only accessible at the point of entrance, being covered in the rest of their course by the obliquus. They are easily discovered at the outer margin, and the excitation of each nerve produces contraction of the corresponding belly of the muscle. The upper portions draw the abdominal wall upwards, and those below the umbilicus draw it downwards. The nerves of the external oblique muscle are to be sought in the lower intercostal spaces, at the origins of the upper digitations of the muscle. Press the electrodes deeply at the free ends of the eleventh and twelfth ribs. There will follow considerable flattening of the abdomen in the region of the contracting portion.

Nerves to Abdominal Muscles.

External Oblique.

The transversalis is powerfully influenced by pressing an electrode on the soft parts on both sides above the crista ilii, near the outer margin of the quadratus lumborum, but even in thin persons this is not always easy. With a strong current, if success is obtained, the action is as powerful as in the strongest voluntary efforts to empty the rectum or bladder. Of the muscles of the back the splenius capitis may be excited at its outer margin. A powerful rotation of the head towards the same side is produced. The other deeper muscles of the neck are beyond reach.

Transversalis.

Splenius Capitis.

The latissimus dorsi, together with the teres major and teres minor, and serratus posticus inferior are generally only accessible to intramuscular excitation.

Latissimus Dorsi.

The Inferior Extremity.

The Crural Nerve.

The crural nerve, after its passage under Poupart's ligament, lies wholly superficial in the groove of the iliac muscle, and is accessible for some distance. Its excitation produces very energetic extension of the leg, with severe pain in the course of the greater and lesser saphena nerves, and of the anterior and middle cutaneous femoral, that is on the front and inner side of the thigh, the knee and inner side of the leg as far as the great toe. Its motor branches can be isolated only in thin persons, but direct excitation of the muscles near the points of entrance of their nerves always produces a powerful effect.

The Obturator Nerve.

The obturator nerve, or at least the mesh of its twigs, since it divides in the obturator foramen, may be reached from the foramen. Place the electrode perpendicularly upon the horizontal ramus of the pubes and strongly compress the skin, fat, and pectineus muscle against the bone. This produces very powerful abduction of the thigh, but it is very painful, partly because the skin is richly supplied with sensitive filaments from the genito-crural nerve, and partly because the obturator itself consists largely of sensitive fibres destined to supply the knee and the inner surface of the thigh.

The Superior Gluteal Nerve.

The superior gluteal nerve is withdrawn by its deep position from direct excitation, as is also the inferior gluteal.

The sciatic nerve, although covered by the thick flexor muscles of the leg, may yet be reached at the lower margin of the gluteus maximus in the middle point between the great trochanter and the tuber ischii, by using firm pressure with a strong electrode, covered by a rather large cushion of sponge or leather. There results a powerful flexion of the leg and contraction of all the muscles of the leg and foot, with acute pain in all the parts receiving sensitive fibres from the nerve.

The Sciatic Nerve.

The peroneal nerve may be reached directly it is given off from the sciatic, on the inner margin of the biceps femoris and of its tendon. The excitation is much more certain and precise at the back of the prominence of the head of the fibula, which affords firm resistance to the pressure of the electrode. In this position also the external and middle sural cutaneous nerves, being given off by the peroneal, above the head of the fibula, escape the action of the current. There results contraction of the peronei, tibialis anticus, extensor digitorum longus and brevis, and extensor pollicis longus, with sensation in the cutaneous nerves of back of the foot.

The Peroneal Nerve.

The tibial nerve, after the division of the peroneal lies in the ham covered only by the popliteal fascia, the skin and a thin layer of fat. From the power of compressing it against a resisting surface it may be excited with as much certainty as the peroneal. There results an energetic contraction of all the muscles of the back of the leg and the sole of the

The Tibial Nerve.

The Tibial Nerve.

foot with painful sensations in the sural nerve and in the sensitive branches of the external and internal plantar. The tibial nerve after emerging from behind the belly of the soleus may be found in the middle line between the inner margin of the tibia and the tendo Achillis, and may be followed downwards as far as the posterior border of the internal malleolus. Contraction of all the muscles of the sole of the foot results, and painful sensations in the plantar digital nerves.*

ELECTRIZATION OF THE CENTRAL ORGANS OF THE NERVOUS SYSTEM.

The Central Organs of the Nervous System.

The central organs of the nervous system, as well as the nerve trunks that pass through the great cavities, on account of being completely surrounded by soft parts and bones which cannot be forced into contact with them by external compression, are withdrawn from the influence of the faradic current, unless it be used of excessive strength. On the other hand an indirect excitation of the brain through the nerves of special sense, especially the optic and auditory, may be accomplished by voltaic currents of medium strength. Besides intense sensations of light and abnormal sensations of sound, excitation of these nerves with strong currents may be followed by vertigo, or even loss of consciousness; and in exciting them the utmost circumspection is all the more necessary since the amount of reaction displayed by different people is widely different.

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* For full details regarding the isolation of single muscles and their physiological action consult Ziemssen, *Die Electricität in der Medizin.* Berlin, 1866; and Duchenne, *Physiologie des Mouvements.* Paris, 1857.

Cutaneous Faradization.

Cutaneous Faradization.

When it is desired to act only upon the skin faradization has many advantages over the other forms of electricity, and in practice it is invariably preferred. There are three methods of applying it.

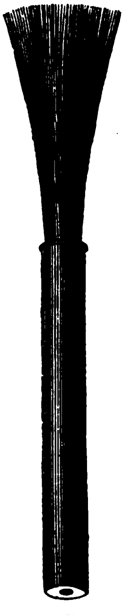
Electric Hand.

1. *The electric hand.*—A moist rheophore (a sponge contained in a cylinder), as shown in fig. 28, is applied to some little sensitive part of the patient's body, the other rheophore is held by the operator, who passes the back of his disengaged hand over the points which he wishes to excite.

Solid Metallic Rheophores.

2. *Solid metallic rheophores.*—The rheophores, figures 28, 29, 31, and 32, without sponges or leathers, and being quite dry, are applied by their metallic surfaces to the skin, and either kept stationary or moved over it with greater or less rapidity, in proportion to the degree of irritation it is required to produce. If the conical rheophore is maintained for some time immovable, it is termed the *electric nail*, from its action somewhat resembling a hot nail penetrating the skin.

Fig. 35.



Metallic Threads.

Metallic Threads.

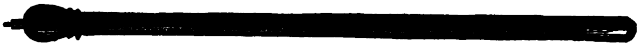
3. *Metallic threads.*—A wire brush (fig. 35). This may be moved over the skin (*electric cauterization*), held in contact with it (*electric moxa*), or used to strike it lightly (*electric fustigation*). In cutaneous electrization the skin must be carefully dried, and in addition sprinkled with some absorbent powder, such as starch or violet powder.

ELECTRIZATION OF INTERNAL ORGANS.

Electrization of Rectum.

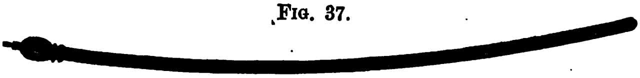
1. *Electrization of the rectum and muscles of the anus.*—A metallic olive mounted on a stem of metal, and insulated by gum elastic is introduced into the rectum and connected with one of the conductors. A moist rheophore connected with the second conductor is moved over the circumference of the anus, while the olive is brought in contact with the levator and sphincter ani. To excite the muscular coat of the rectum the olive must be moved over all its internal surface. The rectum must always be first freed from fæcal matter.

FIG. 36.



Rectal rheophore.

FIG. 37.



Urethral rheophore.

Electrization of Bladder.

2. *Electrization of the bladder.*—The bladder must first be emptied. To electrize the muscular

Electrization of Bladder.

fibres of its neck, the rectal rheophore must be introduced into the rectum as above described. A curved metallic sound (fig. 37), insulated by being covered with an elastic catheter to within an inch of its vesical extremity, is introduced into the bladder, and drawn back in such a manner that its extremity is brought in contact successively with all points of the neck of the bladder. To avoid the necessity of using the rectal rheophore, Duchenne has contrived what he terms a double vesical rheophore. This instrument is formed of two flexible metallic stems, enclosed in an elastic catheter with a double channel separating them from each other. The two stems have the terminations shown in fig. 39, so that when approximated, as in fig. 38, they resemble an ordinary sound. The instrument is closed by pushing the elastic catheter forwards, and is thus introduced into the bladder. The stems being then pushed forward, the ends separate.

FIG. 38.

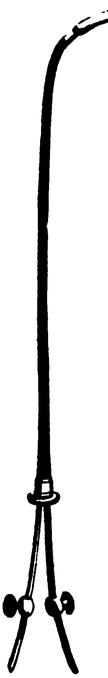


FIG. 39.

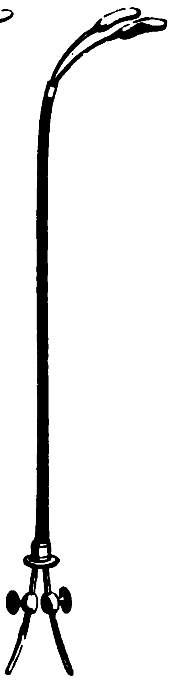


Fig. 38. Double vesical rheophore, closed.

Fig. 39. The same, open.

Electrization of Uterus.

3. *Electrization of the uterus.*—The uterine

Electrization of Uterus.

rheophore differs from the double vesical only in the curvature of the stems, and in the larger size of the terminal plates. It is introduced closed, as in fig. 40, into the vagina, and then the two plates are made to separate, as in fig. 41. The operator guides each of the plates by the index finger of his free hand, and places them on the sides of the cervix.

FIG. 41.

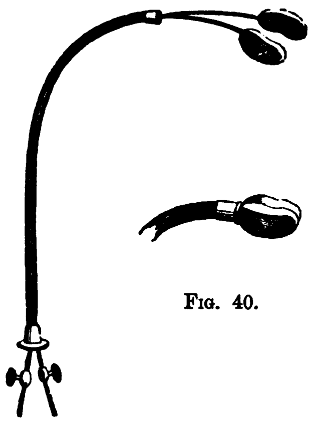


FIG. 40.

Fig. 40. Uterine rheophore, closed.
Fig. 41. The same, open.

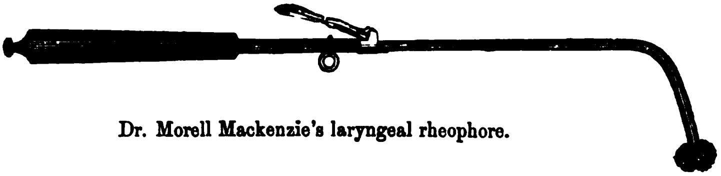
Electrization of Larynx.

4. *Electrization of the larynx.*—This may be direct or indirect. The more usual method is to apply a moist rheophore to the nape of the neck, and a second rheophore, or a wire brush, as the case may be, to the exterior of the larynx, and in the majority of cases this will fulfil every therapeutic indication. In direct electrization the intervention of the laryngoscope is necessary. In this procedure, chiefly practised by Dr. Morell Mackenzie, a curved metallic stem, terminating in a small bit of sponge, and protected by a gum-elastic tube, is introduced by the aid of the laryngoscope. This laryngeal rheophore (fig. 42) is provided with a spring and stop, by which the operator is enabled to withhold the current unless he sees by the laryngeal mirror that the sponge is in the desired position. A

second moist rheophore is applied externally. The muscles of the pharynx may be electrized with a similar director, but this is a proceding requiring great care, on account of the contiguity of the glosso-pharnygeal, pneumogastric, and recurrent nerves.

Electrization of Larynx.

FIG. 42.



Dr. Morell Mackenzie's laryngeal rheophore.

5. *Electrization of the male genital organs.*—Moist rheophores are placed upon the scrotum over the testicle or the epididymis. If it be desired to excite the vesiculæ seminales, the bowel is first emptied, the rectal rheophore is then introduced and so directed that its olive-shaped termination may be brought into relation with the vesiculæ. For this purpose it is sufficient to move the rheophore from right to left and *vice versâ.* A powerful current will penetrate the intestine and reach the vesiculæ, exciting them energetically. The circuit is completed by a second rheophore placed on an unsensitive part of the body.

Electrization of Male Genitals.

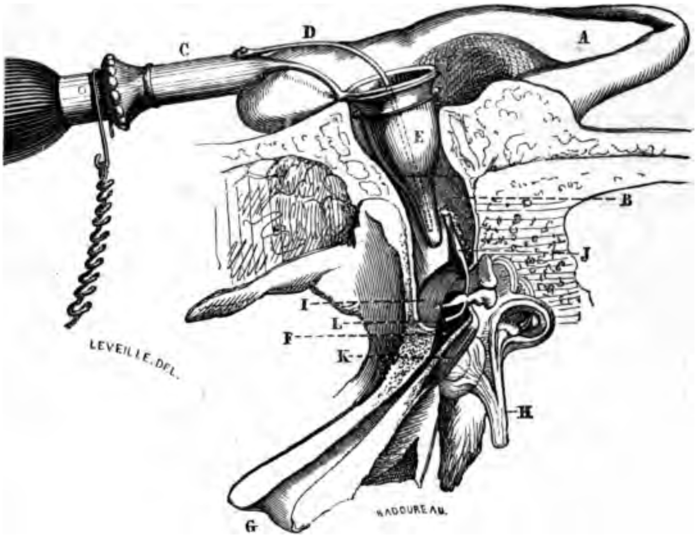
ELECTRIZATION OF THE ORGANS OF THE SENSES.

Electric excitation of the senses of sight, hearing, smell, and taste should be performed with extreme care, from its liability to re-act acutely upon the

Electrization of the Organs of the Senses.

brain. It should never be had recourse to in cases in which central excitement must be avoided, and in all cases the minimum dose should be commenced with. *These cautions are especially important with the voltaic current.*

Fig. 43.*



Rheophore introduced into the auditory meatus.

Electrization of Retina.

Electrization of the retina.—Voltaism has the distinctive property of re-acting acutely upon the retina, producing sensations of flashes of light when the conductors are applied to any part of the face. A moistened rheophore is applied to the closed eye and a second to any part of the face.

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* A. The concha. B. Meatus auditorius externus, in which the rheophore, insulated by a tube of ivory, E, is inserted. The lower half of the meatus is filled with tepid water. F. The tympanum. G. Eustachian tube. H. Labyrinth and auditory nerve. I. Membrana tympani attached to the malleus. J. Laxator tympani externus. K. Tensor tympani. L. Laxator tympani.

Electrization of Auditory Nerve.

Electrization of the auditory nerve.—The external auditory meatus is filled with tepid water, and a metallic rheophore, insulated by ivory or vulcanite, is placed in it, and the circuit completed by a moist rheophore on the neck. The operation is shown in fig. 43.

Electrization of Olfactory Nerves.

Electrization of the olfactory nerves.—A moist rheophore is placed over the back of the neck, and a metal sound, insulated except at its extremity, is moved over all points of the nasal mucous membrane.

Electrization of Nerves of Taste.

Electrization of the nerves of taste.—A rheophore is placed over the back of the neck, and a second is moved over the base and borders of the tongue.

CHAPTER III.

ELECTRICITY AS AN AID TO DIAGNOSIS.

Electro-Diagnosis.

Test of Farado-Contractility.

Test of Voltao-Contractility.

Electricity will assist us in diagnosis only in those conditions in which there is altered muscular contractility, or cutaneous or muscular sensibility, or both. In the normal and healthy state of this tissue muscles and nerves respond to the electric stimulus whatever variety of electricity is employed, but in disease this reaction may be increased or diminished or altogether absent. The irritability of a muscle is tested by ascertaining the lowest power which will cause its contraction. The procedure is as follows :—Assume the case for example to be one of ordinary hemiplegia, say of the left side. Take in one hand the two rheophores of a Faradic instrument in action and apply them to one of the muscles—the extensor communis digitorum will do—of the right or healthy side ; having found the *lowest power* to which the muscle responds, apply the rheophores to the same points of the same muscle on the diseased side, and note whether there is contraction ; if there is, decrease the power of the current, and if contraction still occurs there is increased irritability, or *vice versâ,* as the case may be. In testing with the voltaic current keep one electrode stationary and

Precautions in mode of application.

interrupt the current by gliding the second over the muscle or repeatedly lifting and re-applying it. It is essential that on both sides there should be exact similarity in the application, and that the electrodes should be placed on identical points of the muscle; and this is especially important with the voltaic current, for healthy muscles answer to it more readily when it flows down the limb than when it flows up, and consequently a reversal of the poles will influence the result.* In testing a case of paraplegia where there is equal disease on both sides, you must be guided by a knowledge of the strength of current usually required to bring about contraction. As a general rule, unless a current that causes energetic and painful action in the muscles of the ball of the thumb produce some contraction the irritability is impaired. *In either diagnostic or therapeutic electrization the operator should never use electricity upon a patient without first testing it upon his own hand, and if about to apply it to the face, upon his own face.* This is a most important rule, never to be neglected. There is no certain means of securing that the strength of either a voltaic or faradic current shall not have

Rule for Strength of Current.

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* The current that passes from a nerve centre to the periphery, that is, from the positive electrode placed nearer to the centre, to the negative, placed farther from it, is called a "*direct*" or descending current. The reverse current is the "*indirect*" or ascending. Healthy nerve and muscle respond to a lower power when the current is descending than when it is ascending.

Irritability normal.

varied from day to day, and unless we get into the habit of trusting to our own muscles for fine degrees of graduation we shall often be foiled in our object. In a case of hemiplegia it will be found probably that the irritability to both varieties of electricity is normal. This proves the integrity of the muscular tissue. If the muscle also responds to indirect excitation by its motor nerves, we know in addition that the conducting power of the nerves is uninjured, and that the spinal cord has preserved its integrity at the spot where the nerves are given off. The disease is in the brain. But we may find the irritability somewhat diminished. This in hemiplegia will probably be from disuse and a few faradizations will restore it; if not, there is disease of cord or nerve or muscular tissue, and the disease, as a rule, will be in direct proportion to the amount of diminished irritability. But on the contrary, the irritability may be increased when there is often some rigidity. This points to increased vascularity, irritative lesion of brain or cord, or both.

Irritability diminished.

Irritability increased.

Reaction to Voltaism.

Test now with the interrupted voltaic current. As a rule its reaction will correspond with that of faradism, but in some cases in which response to faradism is diminished or abolished, the reaction to a slowly interrupted voltaic current is not only preserved but greatly increased. On the diseased side the muscles will respond much more readily to the voltaic current than on the healthy side. When this reaction exists,

Voltao-Contractility increased.

that to faradism being lost, it has been shown that the nerves also do not react to faradism, and that the increased irritability is due to the Hallerian irritability inherent in muscular tissue; but why this should be increased over that existing in healthy muscle has not yet been shown. Ziemssen reports a case of purely traumatic facial paralysis produced by a surgical operation in which the trunk of the facial nerve was completely divided. At the end of three weeks the excitability of the motor nerves to faradism and voltaism was lost. The paralysed muscles on the contrary had preserved their irritability to the interrupted voltaic current and responded by a slow contraction, due to the muscular tissue *without the agency of nerve.*

Diagnosis of Peripheral from Central Disease.

This *muscular* reaction to the slowly interrupted voltaic current is often of great use in the diagnosis of peripheral from central paralysis (*e.g.*, in the diagnosis of paralysis of the facial nerve from facial hemiplegia.) Reaction of this kind exists only in peripheral, never in central lesion. In peripheral paralysis there is, in addition, loss of farado-contractility. Observing this in a case of paralysis of the muscles of the shoulder, Duchenne diagnosed local nerve-lesion, and a syphilitic exostosis was afterwards found compressing the nerves. By this same differential reaction it may be determined whether, in a case of paralysis of the extensors of the wrist and fingers, the paralysis is due to the impregnation

Diagnosis of Lead Palsy from Paralysis of Radial Nerve.

of the system by the poisonous influence of lead or mercury, or to rheumatic paralysis of the radial nerve (a most important question as affecting the treatment). In lead palsy the reaction to faradism is greatly diminished or abolished, and that to interrupted voltaism increased. In rheumatic palsy the reaction remains normal, or is increased to both currents.

Cerebral Paralysis.

In paralysis from disease of the brain, Duchenne declares that farado-contractility is always unaltered; but Dr. Althaus, as the result of the examination of upwards of one hundred cases, states that he found the excitability in some diminished and the muscles flaccid, in others increased (these being cases of early rigidity and irritative lesion), and in others normal.

There is no doubt that in the great majority of cases the reaction to all forms of electricity remains unaltered.

Spinal Paralysis.

In paralysis from disease of the cord there is almost invariably diminution of reaction in the affected muscles to all varieties of electricity.

Hysterical Paralysis.

In hysterical paralysis, electro-contractility is, as a rule normal, but electro-sensibility (the sensation of muscular contraction) is absent or much lowerered.

WastingPalsy.

In progressive muscular atrophy (Cruveilhier's atrophy) the farado-contractility is normal in the remaining muscular tissue. Its abolition in this disease proves complete degeneration of the muscle.

Essential Infantile Paralysis.

In the so-called "essential" infantile paralysis, farado-contractility is abolished and voltao-contractility increased. Other forms of paralysis affecting children correspond as regards their electrical reaction to the same disease in the adult.

Diagnosis between Real and Feigned Disease.

The condition of muscular irritability, as tested by electricity, will in some cases largely aid us to distinguish between real and pretended disease. I was enabled to solve this question at once in a case in which simulation was believed to exist, and where I was requested by a railway company, in consultation with Drs. Ramskill and Maclure, to make an electrical examination. In the case in question the muscles of the left leg responded freely to faradism, while the same muscles of the right leg exhibited not a trace of reaction to the full strength of a Stöhrer's induction instrument.

Considered solely as an aid to diagnosis, we can get little more assistance from electricity than I have noted above.

CHAPTER IV.

ELECTRO-THERAPEUTICS.

Limitation of Electricity as a remedy.

THERE is too much belief and too much unbelief in the therapeutic power of electricity. The men who estimate it fairly are quite the minority. It is generally either much undervalued, or else believed to be a sort of modern elixir vitæ, capable of curing a hopeless hemiplegia from destruction of brain tissue, or a paralysis agitans from senile degeneration. Although it will do neither of these impossibilities, yet, considered as a remedy, it is of great value in a wide margin of diseases. It will either stimulate or soothe both nerve and muscle, according to its variety and mode of application; it will frequently restore voluntary movement, it will relieve pain, heighten temperature, recall sensation, coagulate the blood, and dissolve or slowly cause the absorption of tumours.

Effects upon Nutrition.

Besides its local and immediate action, it exerts also general effects, especially upon nutrition. Sir James Paget, in his Surgical Pathology, quotes an experiment in which the nerves of a frog's hind legs were divided, and while one limb was left inactive the muscles of the other were called into frequent action by faradizing the lower end of its nerve; the result was that at the end of two months these muscles retained their weight and texture, and their capacity of contraction, while the others were degenerated in texture, and had also lost some of their power of contracting. Legros and Onimus electrized with the voltaic current some puppies for a quarter of an hour every day, by placing one of the fore paws and one of the hind ones in tepid water connected with electrodes. At the end of six weeks those that had been electrized weighed more and had grown larger than those of the same litter that had not been electrized. Heidenheim found that the prolonged action of a continuous current upon an exhausted muscle produced a restoration of it; that is, that the depressed excitability increased, and that even in a dead muscle the lost excitability was again established.

Effects upon Nutrition.

Besides effects upon nutrition, electricity may increase the secretions—in amenorrhœa it may re-establish the catamenia—and it acts generally upon nerve and muscle as a stimulus, putting both into a condition which has been termed electrotonus. Its modification of the natural state of the electricity of the human body does not cause, as a rule, any appreciable effect; but in certain pathological conditions of the nerves it is otherwise. Some persons even are extremely sensitive to electric changes in the atmosphere, and Duchenne cites the case of a

Upon the Secretions.

lady who was invariably during a thunderstorm stricken for some hours with general paralysis. In many of these exceptional instances a feeling of faintness, giddiness, headache, nausea, or even vomiting may result—a fact which it is well to bear in mind.

General Electrization.

Electricity has been, and indeed is still, advocated by some writers as of great benefit in a multitude of diseases. I have had no experience of its application in any other than in disorders of the nervous system, and chiefly in paralysis, neuralgia, and other painful affections, and in some disorders in which tremor or spasm is a prominent symptom.

Before discussing its localized action, I may refer to a methodical application to the whole surface of the body, which is advocated by Drs. Beard and Rockwell under the name of General Electrization. They state that they have had experience in more than ten thousand applications, and they speak very highly of its remarkable effects administered in this way in conditions of debility. Their method rests, they say, upon the two principles,—"1. That electrization, besides being merely a local stimulant, also exercises an influence over general and local nutrition, at once unique and unrivalled, and that entitles it to the highest rank among constitutional tonics. 2. That the system of making the application exclusively local is both illogical and inconsistent; that in the use of electricity, as of every other remedy, constitutional diseases should be treated constitutionally." Their method of procedure is to place the patient with his naked feet upon a sheet of copper connected with one pole, usually the negative; the other pole is connected by a moistened sponge with the left hand of the operator, who passes his disengaged hand over the muscles of the patient, and sometimes over his whole body. The originators claim for this method a delicacy of graduation to which they attach great importance, not to be equalled by any mere mechanical means; the sensations of the operator, the current passing through his body, are his guides to graduation; and they say also that no artificial rheophore can equal the human hand in its adaptability to the different regions of the body. My experience of this method has not been sufficient for me to decide upon its merits. The reader will find it fully described in the work of its authors.* There is another general application which may be of occasional service. This consists of a bath the water of which is in contact with one of the conductors of an induction instrument, or of a battery supplying an interrupted voltaic current, while the second conductor is applied to some part of the body that is not immersed, commonly to the upper and

General Electrization.

The Electric Bath.

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* A Practical Treatise upon the Medical and Surgical uses of Electricity, by Drs. Beard and Rockwell. New York: W. Wood and Co. 1871.

back part of the chest. The spinal cord is excited in a general manner by reflex excitation of the peripheral ends of the nerves. This form of application is useful in cases where stimulation of the nervous centres is indicated; and given of so feeble a strength as not to provoke muscular contraction, it produces an excitation that will increase muscular power in certain forms of general paralysis. In cases of general debility I believe that these baths are of decided benefit.

Franklinization.

Franklinization, as partaking more of a general application than a local, may be conveniently discussed here. It has been suffered to fall into unmerited disuse, perhaps from the inconveniences of its application. It has been found in the practice of the National Hospital for the Paralysed and Epileptic, and in private cases coming under my own observation, of considerable value. *Facial neuralgia*, for example, which has resisted other modes of treatment, may occasionally be relieved with rapidity and permanently by drawing sparks along the track of the affected branch or branches of the trifacial nerve. Sometimes also *obstinate sciatica* has been partially or altogether removed; as was also a remarkable case of *facial spasm* (tic convulsif) in a hospital patient. A female, 48 years of age, had suffered for thirteen years from spasm of the muscles of the left side of the face. The distortion produced by the spasm was very great, and was apt to

(a) Facial Neuralgia.

(b) Sciatica.

(c) Facial Spasm.

be so much exaggerated by slight emotion, even such as would be caused by having to address a stranger, as to make speaking difficult, and to prevent proper attention to her occupation as a small shopkeeper. An experimental trial was made of electrization by sparks along the lines of the nerves distributed to the affected muscles. After the third application the spasm was manifestly relieved, the distortion being diminished, and the consecutive paroxysms occurring less frequently. By persisting with this treatment thrice weekly over a period of two months, so great an amount of relief was obtained that little distortion of the face remained, and the patient was able to pursue her business with comfort. Electrization by sparks over the larynx has been found so effective in the relief of cases of hysterical or *emotional aphonia*, even those of long standing, that it is now almost invariably used in the practice of the hospital in the treatment of these cases before having recourse to induced electricity. In six or seven recent cases, repeated twice or thrice this form of application effected a complete cure. One of these cases was of nine, another of six months' duration. The remainder had lasted from four weeks to three months. The seventh case did not receive any benefit from the use of static electricity, and the other forms of the agent proved equally ineffective. The case recovered slowly under general treatment. Electrization by

(*d*) Emotional Aphonia.

(e) Localized Excessive Sensitiveness.

(f) Tremor.

sparks over the affected spot has often proved of great benefit in removing the *localized excessive sensitiveness* not unfrequently found in hysterical cases, particularly in the spinal region. *Tremor*, whether general or local, is sometimes largely relieved by insulating the patient, and charging him with positive electricity for a period of twenty minutes to half an hour. Other applications failing, I would advise always in cases similar to the above, a fair trial, say half a dozen sittings, of Franklinization.

Dr. Radcliffe's Mode of Electrization.

There is a special method of electrization originated by Dr. Radcliffe, and which has in it very much to recommend it both in theory and practice. The investigations of this distinguished physician in animal electricity lead him to the conclusion that the primary condition of this electricity is not current but static.* The state of muscle and nerve during rest is that of charge, during action of discharge. The sarcolemma is proved by many experiments to be sufficiently non-conducting to allow it to act as a dielectric, and so also the neurolemma. Positive electricity having its origin in the molecular reaction of the blood and elsewhere, is developed on the outside of the sarcolemma or neurolemma, and as their sheaths are dielectric the effect of this development is the *induction* of an equivalent charge of negative electricity on their insides. Hence the sheaths of the muscular and nerve fibres become charged precisely as a Leyden jar is charged. Hence, also, the particular view of muscular action which Dr. Radcliffe advocates, namely this, that the elongation of muscular fibre is caused by the elastic sarcolemma being compressed at right angles to its surface by the mutual attraction of the two opposite electrical charges disposed on its two surfaces (an idea which is proved to be practicable by a most ingenious experiment), and that the contraction follows upon discharge in consequence of the sheath being then liberated from the cross compression and left free to yield to its own innate elasticity. The sheaths of nerve fibres are subjected to the same pressure of the two opposite charges, but they do not exhibit the same elongation under charge and contraction on discharge because they are less elastic than the muscular fibres. This view explains all the electrical phenomena of muscle and nerve as well as the current theory of Du Bois-Reymond, and it leads to important consequences in electro-therapeutics. If the sheaths of the muscles and nerves are thus dielectric it is to be supposed that an artificial charge of positive or negative electricity will affect them like the natural charge. If the outside be supplied with a positive artificial charge, an equivalent negative charge will be induced on the inside, and *vice versâ.* Moreover, if the natural charge was one in which the outside of the sheath was positive, it was to be

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* Dynamics of Nerve and Muscle, by C. B. Radcliffe, M.D., &c. London: Macmillan & Co. 1871.

Dr. Radcliffe's Positive Charge.

supposed that the communication of positive electricity to the outside would be favourable to the irritability of the nerve or muscles, and so, indeed, it proved to be by many experiments, and not only so, but also that the opposite charge of negative electricity is less favourable. It was shown in fact that irritability may be long preserved, and renewed more than once by the positive charge, in a way which could not be done by the negative charge. The experiments are too many to be introduced here, but the conclusion from them is applicable not to statical electricity only, but also to voltaic electricity, for Dr. Radcliffe shows good reason to believe that voltaic electricity acts upon irritability not by its current so much as by *the charge associated with this current,* which charge may be made positive or negative by putting an earth wire to one or other of the poles. At all events, when a part of the body is included in the voltaic circuit it may be all *charged* with positive electricity if an earth wire be put to the negative pole, or with negative if an earth wire be put to the positive pole; and the conditions are favourable to irritability in the former case, unfavourable in the latter. This is the fact insisted upon. It is of no moment whether this charge with which the animal Leyden jars are to be charged is from a friction machine, or whether it be from a voltaic battery by running off the opposite electri-

Dr. Radcliffe's Positive Charge.

city by an earth wire. What is wanted is to charge the outsides of the sheaths positively as they are charged naturally. What is aimed at is to put the fibres by this means in the condition most favourable to the preservation or recovery of their irritability—*not to provoke this irritability into existence by shocking it;* and certainly there is much in theory and much in practice to recommend this view as one which opens out quite a new field in electro-therapeutics. Before long I trust there will be something definite as regards practice to be said respecting it.

Dr. Radcliffe's Positive Charge.

The question of the differential use of the voltaic current, as well interrupted as constant, and that of faradism, has been largely discussed of late years, and for some time divided electro-therapeutists into two great schools, the Faradists, led by Duchenne, in France, and the Voltaists by the late Professor Remak, in Germany. The advocates of the voltaic current claim for it an action *sui generis* upon the nervous centres, an action which faradism can in no way replace. Benedikt, in his "*Electrotherapie,*"[*] contends that the voltaic current will *directly* affect the brain and cord. He advises, in cerebral disease, that it should be applied to the long or short axis of the cranium, sittings not to exceed thirty

Differential Use of Voltaism and Faradism.

Electrization of Brain.

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[*] Electro-Therapie, von Dr. M. Benedikt. Vienna: 1868.

seconds, and to be stopped instantly on the occurrence of the slightest giddiness. The electrodes must be maintained immovable, and may be applied to each mastoid process, to each temple, or to the frontal and occipital protuberances. He advocates still more strongly, for symptoms of intracranial origin, the so-called "galvanization of the sympathetic"—its cervical ganglia. One electrode may be deeply pressed into the auriculo-maxillary fossa, and the other, with a good-sized sponge, applied over the sixth or seventh cervical vertebra, or to the manubrium sterni, close to the border of the sternomastoid. The duration of the application should be from one to three or four minutes and with from ten to twenty cells. Whether voltaization can be localized in the sympathetic or not, very powerful effects are produced by the electrodes placed in the above positions, and *when so applied the greatest caution must be exercised by the operator, as also in cerebral galvanization.* Giddiness, syncope, and convulsions are recorded as the sequel of a too powerful or too prolonged application. Benedikt also advocates galvanization of the cord, by keeping one sponge, usually the positive, stationary, and moving the other up and down by the sides of the vertebræ, about forty times at each sitting; or by one pole on the spine and the other on a nerve or muscle. After galvanization of the nervous centre has restored voluntary power he advises that the nutrition of

"Electrization of Sympathetic" (so-called).

Electrization of Cord.

the muscles should be aided by localized faradization. This question of the therapeutic value of direct voltaization of the great nervous centres is still *sub judice.* The reader will, in any such operation, do well to remember the cardinal rule never to apply electricity to a patient until he has first tested it upon himself.

Relief of Pain.

Electricity has been fully proved to be sometimes unapproached in its power of *relieving pain.* None of its therapeutic results is more firmly established, and were it in no other respect of use, its services here would entitle it to the foremost rank as a remedy. I refer especially to its application in neuralgia. The constant voltaic current is the form in which it must almost invariably be applied, both electrodes being held firmly pressed and immovable upon the skin. Faradization is seldom of any use except with the wire brush as a counter-irritant. Franklinization, if voltaization fails, should always be tried, the patient being insulated and simply charged with static electricity by being connected with the prime conductor, while the machine is kept in rotation for about fifteen minutes. If this fails, sparks may be drawn in the track of the affected nerve or nerves; but the voltaic current in nineteen cases out of twenty, where electricity is advisable, must be our resource. The electrodes should be so applied as to include in their circuit the part or nerve affected. The number of

Relief of Pain. cells should be the highest number that the patient can bear without pain or discomfort The length of application should be from five minutes to ten minutes, and the frequency once or twice a day. Dr. Althaus considers that the positive pole should always be applied to the seat of the disease. In my experience I have not found the direction of the current of importance, but only that it should be *constant*. The seat of the disease in true neuralgia is always in the posterior nerve-root, and one of the electrodes should be placed as nearly over this as possible. I generally place the negative pole with a large sponge, on the spine over the point of origin of the nerves affected, and apply the positive pole to the painful spot, and if there be more spots than one, to the different spots in succession. The result of this is almost uniformly good, and it is seldom that considerable relief is not afforded, even if a cure do not result, and this in most varieties of neuralgia, whether centric, reflex, or constitutional. The number of cells must be regulated according to the region affected. In the face it is best to commence with about five, as the sensitiveness of the retina varies so greatly. On the occurrence of the least giddiness the application should be discontinued and fewer cells used. The battery being in good order, about fifteen or twenty cells will be the maximum applicable to the face, which may be increased in other parts of the body; but

Relief of Pain.

the practical guide must be, as stated above, the highest number that can be borne without discomfort. Professor Eulenberg, who has had wide experience, considers sciatica as by far the most curable of neuralgiæ—many cases requiring only from three to five sittings. Intercostal neuralgia he has never known benefited. In ordinary trigeminal neuralgia he speaks strongly of the constant current as a palliative, but doubtfully of its power to cure. In cervico-brachial neuralgia it divides, he says, the field with hypodermic injection of morphia. Dr. Anstie, while endorsing this, places a considerably higher estimate on its curative power in ordinary trigeminal neuralgia, and he quotes two cases treated by Professor Niemeyer. "The patients," he writes, "were respectively aged sixty-four and seventy-four, and the duration of the neuralgia had been respectively five, and twenty-nine years; in both the pain was of the most severe type, and in both the success was most striking. In one, every possible variety of medication, and several distinct surgical operations for excision of portions of the affected nerve, had been quite vainly tried. The cases are altogether among the most interesting facts in therapeutics that have ever been recorded." Galvanization of the cerebral hemispheres has been found very beneficial in true migraine (sick headache): the electrodes may be applied to each temple or to each mastoid process. Begin with not more

Relief of Pain. than two or three cells, and for not longer than a minute, and stop upon the occurrence of the least giddiness. In angina pectoris one pole may be applied to the spine and the other to the cardiac region. Neuralgia of other parts must be dealt with according to the rules of application already enunciated. The reader will find the subject very exhaustively considered in Dr. Anstie's work.* He quotes some extremely severe cases in which the effect of the current was to arrest the pain in a few sittings, and to procure a remission for several days or even weeks; and I have had several cases which I believe to have been as fairly cured as an ague fit may be said to be cured by quinine. Dr. Russell Reynolds also quotes the case of a patient, a lady, who for twenty years had suffered from an extremely severe neuralgia of the ophthalmic branch of the fifth, which recurred daily and from which her health had greatly suffered. It was not only relieved but removed by a single application.

Paralysis. But it is in the many disorders that are classed under the heading of paralysis, that the chief field for the employment of electricity is found, and especially for its localized employment. In all cases the first step is to ascertain the condition of the muscles as regards their irritability to the interrupted

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* Neuralgia and the Diseases that resemble it. By Francis E. Anstie, M.D., &c. London: Macmillan and Co. 1871.

Paralysis.

voltaic and faradic currents. They must be tested as described at page 78. Having found the degree of reaction, it is as a general rule, to which, however, there are some exceptions, advisable to treat them with that current to which they most readily respond. Where, *after three or four applications*, there is no contraction under either current, electricity will do no good. Where reaction is normal it will usually not aid us in restoring voluntary power, though it may prevent the muscles from wasting; but where reaction is only lessened it will often prove of the greatest service, and in all cases it is likely to preserve the nutrition of the muscles, a point which in protracted paralysis is of the highest importance. In such cases, if we can do no more, we should endeavour, in the words of Sir Thomas Watson, "to preserve the muscular part of the locomotive apparatus in a state of health and readiness, until peradventure that portion of the brain from which volition proceeds, having recovered its functions, or the road by which its messages travel having been repaired, the influence of the will shall again reach and reanimate the palsied limbs."

Irritability to Voltaism increased.

But there are other instances in which, although the muscles give no response to faradism, their irritability to the interrupted voltaic current is not only preserved but increased. Under the use of this current the increased irritability will usually diminish; ten cells will soon be wanted to produce the

Paralysis. Irritability to Voltaism increased.

amount of contraction that at first was given to five, and then ensues generally a gradual return of response to faradism. Use then faradism only. There is a remarkably interesting record of a case of paralysis of the deltoid, which illustrates the above treatment, in the *Lancet* for 1866, vol. ii. p. 576. It occurred in the practice of my predecessor at the National Hospital for the Paralysed and Epileptic, Mr. J. Netten Radcliffe. The patient was a blacksmith aged 25 years. After several days' suffering from severe "rheumatic pains," so called, in both shoulders, but particularly in the left, he lost suddenly, while working with an ordinary sized hammer, one morning, the power of raising his right arm. When first seen, five weeks after this occurred, the deltoid and infra-spinatus muscles of the right side were found to be completely paralysed, and there was some wasting of the former muscle. The contractility of both muscles to faradism was annihilated, the electric sensibility was diminished over the infra-spinatus, and this form of sensibility, as well as the sensibility to heat, cold, tickling and touch, was absolutely wanting in a triangular space (the apex pointing downwards) over the deltoid, measuring two inches and a half at the base, and five inches from the base to the apex. Under powerful faradization seven times repeated at intervals of three days, not a trace of contraction could be excited in the paralysed muscles, and the wast-

Paralysis. Irritability to Voltaism increased.

ing evidently increased. The interrupted voltaic current was then tried. With thirty-five cells of a Becker-Muirhead battery, which produced no effect on the healthy left deltoid and infra-spinatus, a marked contraction of both paralysed muscles was excited, with forty-five cells (also ineffective upon the healthy muscles) an energetic contraction. Mr. Radcliffe from this time used the interrupted voltaic current only, thrice weekly, and each time about ten minutes, until it had been applied thirty times. At the end of this period seventy-five cells were required to produce the amount of contraction formerly caused by forty-five, and under the full force of the current from the primary coil of a large Stöhrer's induction apparatus, slight contraction was produced in the deltoid. The further wasting of the muscles appeared also to have ceased, although they did not gain in bulk.

At this time treatment was suspended for two months, the patient being compelled to leave town. In the interval, not only was the little ground which had been gained by electrical treatment lost, but the paralysed muscles had become more and more wasted, and it was now clear that the supra-spinatus also suffered. The wasting indeed was so great that of the deltoid barely a filmy layer of fibres could be perceived to remain. Faradization over the affected muscle did not excite a trace of contraction. But again the interrupted voltaic current

Paralysis. Irritability to Voltaism increased.

caused marked contraction, and pursuing the same course that he had done before, Mr. Radcliffe used daily, for about a dozen times, this form of current only. At the end of the twelve applications, on using the full force of the current from the primary coil of a large Stöhrer's induction instrument, distinct but slight contraction of the deltoid and infraspinatus occurred. From this period faradization of the paralysed muscles was persisted in four times in the week.

The history of this case was not completed in the account given by the *Lancet* reporter. I am now able to give the result. The affected muscles steadily increased in bulk, their electro-contractility improved, sensibility to the electric current, touch, tickling, heat and cold, returned, and at the end of four months the patient was enabled to use his right arm freely and return to his ordinary occupation. At this time no difference in appearance could be distinguished between the right and left deltoid, and voluntary control was as complete over the one muscle as the other; but the electro-motility of the right muscle was not equal to that of the left. In the autumn of 1869 this case came under my observation. During the interval the man had followed his occupation, using with freedom even the large hammer. But about four weeks before placing himself under medical care again, he had begun to suffer from severe

Paralysis. Irritability to Voltaism increased.

erratic pains in the right arm and forearm, and an inability to wield the hammer freely. In bulk of muscles and voluntary action no difference could be detected between the right and left arms. The right deltoid was apparently as fully developed as the left. There was no alteration of sensibility of any form over the right arm, and all the muscles responded to an induced current of ordinary strength, an interrupted voltaic current producing no contraction until its force was raised to a point that it would act upon healthy muscles. But the motor effect produced on the right deltoid by induced currents of equal strength was much less than on the left.

I had under my care recently a gentleman who had resided for some years upon the west coast of Africa. The muscular symptoms were those of lead palsy; the extensors of the fingers and the muscles of the thenar eminence had almost entirely disappeared in both arms, there being complete flattening of the ball of the thumbs. There was no lead line and no history of lead, but there was enlargement of the liver, and there had been more than one attack of jaundice. The voluntary movements of the affected muscles were almost entirely abolished. The wasting and loss of power began, after an attack of remittent fever, about two years since, and in nine months had reached their present condition, when the patient returned to this country for treatment.

Paralysis. Irritability to Voltaism increased.

Iodide of potassium, sulphur and alkaline baths, and other remedies administered for some months, had caused no improvement. On testing the affected muscles there was not a trace of reaction to the full strength of Stöhrer's induction instrument, but distinct contraction to the interrupted voltaic current from ten cells of the Becker-Muirhead battery. The reaction in the other arm muscles was normal to both currents. The interrupted voltaic current from twenty of Muirhead's cells was localized in the wasted muscles for ten minutes, and they were then faradized for ten minutes. This was repeated thrice a week for four months, the strength of the voltaic current being gradually increased. At the end of this time the muscles were fairly well developed, and their voluntary power for all movements was restored, though a little awkwardness remained. There was no reaction to less than thirty-five cells of Muirhead's battery, and there was no return of reaction to faradization. No medicine was taken during the treatment. My patient has returned to Africa, armed with an induction and a voltaic instrument, and I have since heard from him that he continues well.

Traumatic Paralysis.

In cases of atrophic paralysis from traumatic injury of the nerves, faradization is indispensable. In the cases of men wounded in the civil war in America, it was largely tested in the hospitals of Philadelphia, and the surgeons specially selected for

Traumatic Paralysis.

its investigation report as follows:—"The only important means in the treatment of paralysis from default of innervation is faradization by the method of Dr. Duchenne. Most of our cases were from wounds that were of old standing when they came under our care, and localized faradization proved of the utmost value. In some cases, at a single application it restored the power of movement to parts long deprived of it, and we have seen very few instances in which there has not been improved nutrition and greater sensibility and strength when we were able to continue it sufficiently long."* Duchenne reports cases which were of many years standing, and in which the paralysed limbs were so wasted that the muscles, whose farado-contractility was also abolished, appeared to have quite disappeared. Their sensation and temperature were diminished, the cutaneous veins contracted, and the skin shrivelled, and often purple. Under direct faradization sensation and temperature were quickly restored, the natural colour of the skin returned, the muscles gradually increased in bulk, and regained their voluntary movements, and afterwards their farado-contractility. The following is a typical example.

A printer, 19 years of age, was injured on

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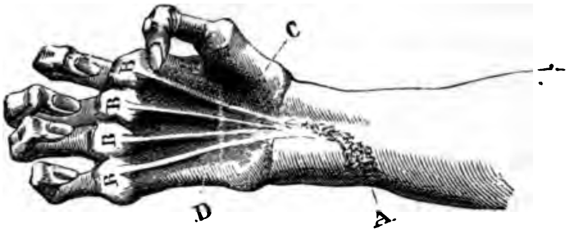
* S. Weir Mitchell, George R. Morehouse, and W. W. Keen. "Gun-shot Wounds and other injuries of Nerves." Philadelphia: 1868.

Traumatic Paralysis.

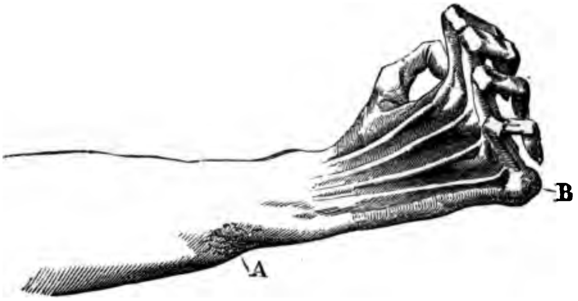
the inner side of the forearm by a cutting instrument, which penetrated about an inch above the metacarpus, grazed the anterior surface of the ulna, and passing within the tendon of the palmaris longus, lacerated all the tendons in front. The flexor carpi ulnaris, inner fibres of the superficial and deep flexors, the palmaris brevis, and the ulnar nerve and artery, must consequently have been severed. In three months the wound had healed, but the hand was atrophied, and the last

Fig. 44.



Hand before Treatment. Palmar surface.

Fig. 45.



Hand before Treatment. Dorsal surface.

Traumatic Paralysis.

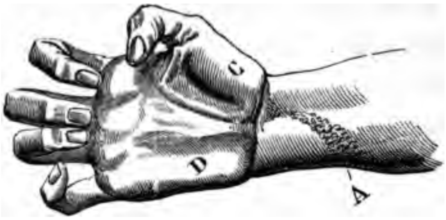
two phalanges were rigidly flexed, and in the fourth and fifth fingers could not be mechanically extended, owing to the retraction of the cicatrix (A, fig. 44) to which their flexor tendons adhered. These bands were ruptured by gradual extension, but complete paralysis remained. Figs. 44 and 45 show the hand before treatment. The injury of the ulnar nerve caused atrophy of the interossei, and the last two lumbricales. The muscles of the forearm were unaffected, and being unopposed, the phlanges were drawn into a claw-like deformity ("*main en griffe*"). This deformity was still more pronounced when the patient endeavoured to extend his fingers. For four years every sort of treatment was tried in vain. Faradization was then commenced on alternate days, and localized in the interosseous spaces, and the thenar and hypothenar eminences. A powerful and painful current was used. After ten sittings the patient felt a burning sensation, the hand was observed to be less atrophied, and the interosseous spaces to be slightly filled in, the first phalanges less flexed, and the second begun to extend. Circumstances obliged him to suspend treatment for three weeks, and when it was resumed the improvement had been maintained. Cutaneous faradization was now added, and sensation greatly improved, and the cutaneous veins, which had not been visible, began to reappear. Development of the small muscles of the hand followed, with improvement in the attitude

Traumatic Paralysis.

of the fingers. Next, the heads of the metacarpi ceased to project.

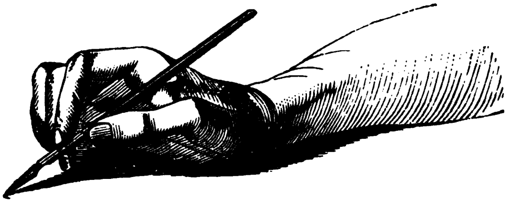
Reckoning on a gradual and spontaneous cure, the patient again discontinued treatment for two months, at the end of which time he had made no further progress. Treatment was resumed, with steady improvement, and gradual return of voluntary power, until he was even able to write.

Fig. 46.



Hand after Treatment. Palmar surface.

Fig. 47.



Hand after Treatment.

Fig. 46 shows the hand after treatment, as the patient endeavoured to place it in the deformed position (fig. 44) that it had before treatment. Fig. 47 shows the attitude of the hand when writing. It will be seen from fig. 46 that he could

Traumatic Paralysis.

not succeed in dislocating the first phalanges upon the metacarpi, their old deformity; that the heads of the metacarpi are now in their normal state; that the flexor tendons are no longer seen projecting in the palm; that the thenar and hypothenar eminences are developed; and, finally, that the fingers have lost their bony appearance.

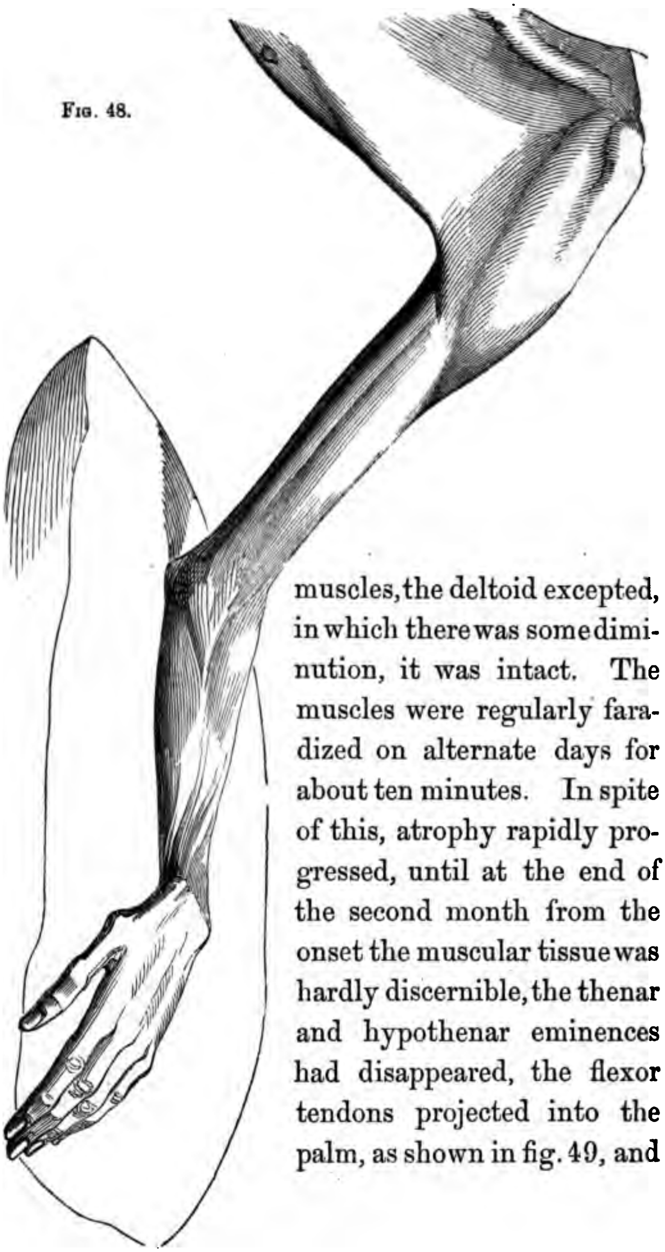
Faradization is only of use *after the nerve has been reunited,* a process requiring time; for it would be irrational to expect benefit as long as the ruptured nerve is physically incapable of transmitting the mandates of the will. Nature will not effect a cure spontaneously by mere lapse of time, for in the above case no less than four years had passed without improvement.

The next case is an example of the inutility in such cases of recent faradization.

A man was admitted into the Hôtel Dieu with a dislocation of the head of the humerus into the axilla. It was reduced under chloroform, when it was found that the muscles of the arm, forearm, and hand were completely paralysed. Sensation was not affected. A month after, when Duchenne first saw the patient his state was unchanged, except that there was considerable atrophy of the paralysed muscles, and sensation was lowered about one half. Farado-muscular contractibility was abolished to either direct or indirect excitation in all the muscles of the hand, forearm, and arm. In the shoulder

Traumatic Paralysis.

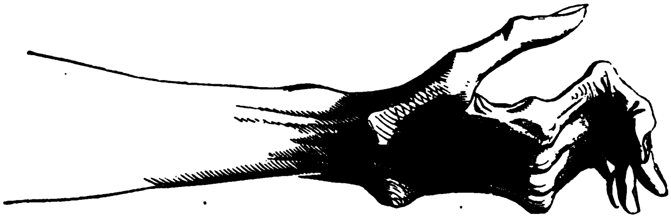
FIG. 48.



muscles, the deltoid excepted, in which there was some diminution, it was intact. The muscles were regularly faradized on alternate days for about ten minutes. In spite of this, atrophy rapidly progressed, until at the end of the second month from the onset the muscular tissue was hardly discernible, the thenar and hypothenar eminences had disappeared, the flexor tendons projected into the palm, as shown in fig. 49, and in the dorsal surface were deep hollows from wasting of the interossei. It was six months before flexion and extension of the forearm were regained, and four years before the development of the muscles again equalled those of the uninjured side. Although there was complete restoration of voluntary power, there was no return of farado-muscular contractility. Fig. 48 shows the arm one month after the accident, the deltoid is but slightly atrophied, but the arm and forearm are one third less in circumference than on the uninjured side. Fig. 49 is the palm of the hand two years after the accident. Fig. 50 the arm after the end of treatment. We see then that in traumatic paralysis the regular application of faradism from its onset, does not prevent the muscles from almost complete atrophy, but its use, after repair of nerve lesion, will restore their development, nutrition, and voluntary movement.

Traumatic Paralysis.

FIG. 49.



But it is in these recent cases of traumatic paralysis that the interrupted voltaic current should be localized in the wasted muscles.

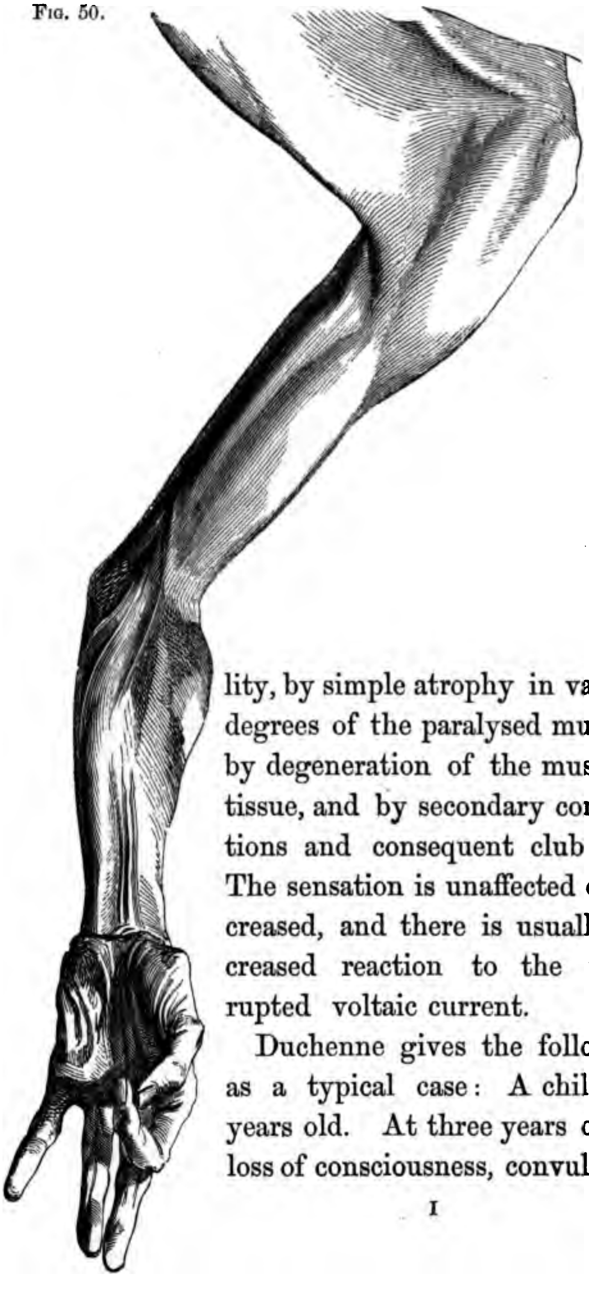
Traumatic Paralysis.

I have now under my care a gentleman who was sent to me by Sir James Paget. Five months ago, as the result of a stab which probably divided the supra-scapular and circumflex nerves, there was complete loss of power in the deltoid and supra and infra-spinatus muscles. Two months afterwards, when I first saw the patient, these muscles had almost completely wasted away. The electro-sensibility of the little muscular tissue that remained was greatly diminished, the contractility to faradism abolished, but that to the interrupted voltaic current from thirty cells of the Becker-Muirhead battery was retained. For the past two months I have daily applied the current from fifty cells; holding the sponge from the positive pole stationary upon the centre of the deltoid, and painting, as it were, every part of the affected muscles with the sponge from the negative pole for ten minutes. There has been a considerable return of power; the development of the wasted muscles is remarkable and the result of the treatment most satisfactory.

Infantile Paralysis.

Duchenne strongly advocates faradization in the essential paralysis of infancy, a disease to which he has devoted much attention. Under the term "infantile paralysis" many different forms of paralysis are liable to be included, but the variety now to be considered has the following history. It is characterized chiefly by motor paralysis occurring suddenly, by greater or less diminution of farado-contracti-

FIG. 50.



Infantile Paralysis.

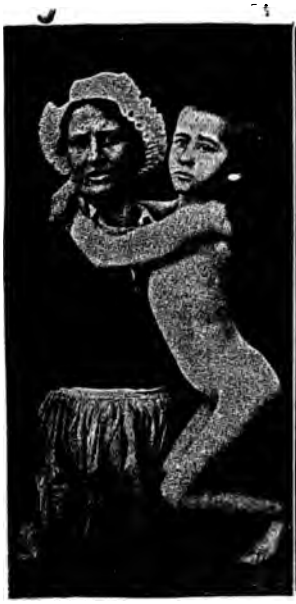
lity, by simple atrophy in various degrees of the paralysed muscles, by degeneration of the muscular tissue, and by secondary contractions and consequent club feet. The sensation is unaffected or increased, and there is usually increased reaction to the interrupted voltaic current.

Duchenne gives the following as a typical case: A child 11 years old. At three years of age loss of consciousness, convulsions,

Infantile Paralysis.

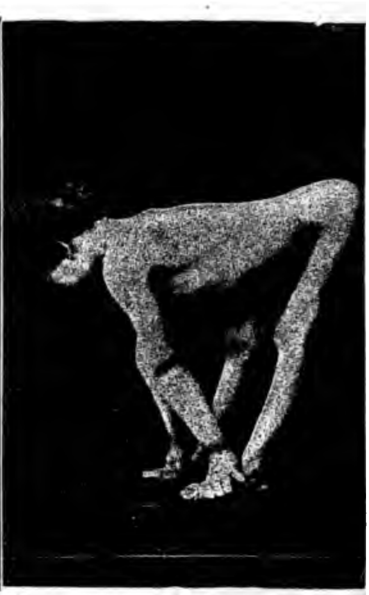
and paralysis of both legs occurred. In a month he could sit up, but there was no return of power in the legs and they rapidly wasted. There was never any affection of the bladder or rectum. The state of the child eight years after the onset of the disease was as follows:—The skin literally adhered to the bones, as shown in figs. 51 and 52, engraved

FIG. 51.



Infantile Paralysis.

FIG. 52.



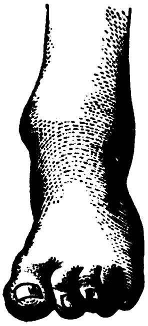
Infantile Paralysis.

from photographs. No reaction to faradism. He could neither move his toes, feet, or legs, and if he were set up upon his feet the joints flexed one upon another, as seen in fig. 51. But like all similar

Infantile Paralysis.

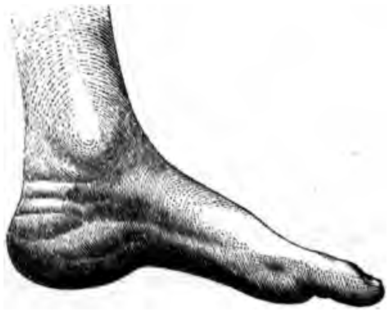
cases, the child began to get along by sitting down and pushing or dragging himself with the aid of his hands, and he soon found out a more rapid mode of progress. Propping himself, as in fig. 52, he seized his feet with his hands and carried them forward one after the other.

Fig. 53.



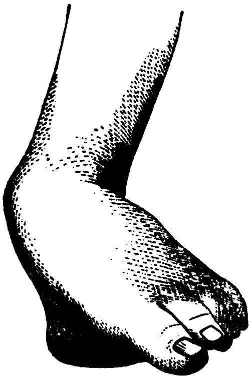
Infantile Paralysis.

Fig. 54.



Infantile Paralysis.

Fig. 55.



Infantile Paralysis.

The subsequent deformity of the limbs in infantile

Infantile Paralysis.

paralysis depends less upon the number than on the functional importance of the paralysed muscles. The foot is less deformed and the movements of the leg less affected by the loss of all the motor muscles of the foot than by the paralysis only of certain amongst them. Figs. 53 and 54 are from photographs of a foot all of whose muscles were paralysed and atrophied. The side view, fig. 54, is almost normal, and in a front view, fig. 53, the only deformity is a less development than the sound foot. Whereas a single muscle only being atrophied, greater deformity results, as in fig. 55, in which the gastrocnemius alone is paralysed.

Duchenne states that faradization applied in good time, when atrophy is but commencing, is calculated to abridge the duration of the paralysis, diminish if not arrest the wasting, and perhaps prevent the fatty transformation of the muscles. Those muscles, although paralysed, whose reaction to faradism is retained, will under its application quickly regain their power. There is no ground for the feeling of natural repugnance that exists against subjecting children of such tender years, sometimes indeed hardly three months old, to such excitation. Used with slow intermissions, children as a rule betray no sign of pain, if the precaution is taken of gradually inuring them to the strange but not painful sensation which accompanies muscular contraction, and before long the operation even amuses them.

Infantile Paralysis.

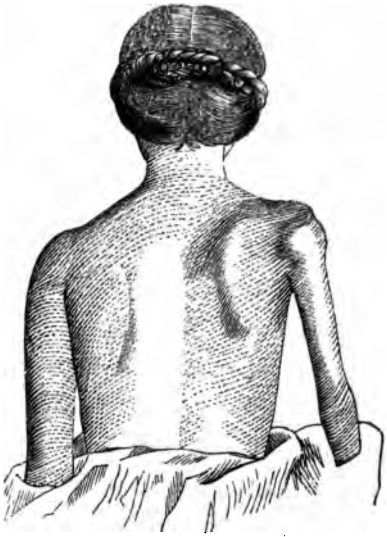
As a rule, during the first sitting, I use only moistened sponges, and allow no current to pass, and I am always well provided with sugarplums as bribes.

But it is nearly always at a very advanced period of the paralysis, when all kinds of treatment have been vainly exhausted, that people appeal as a forlorn hope to electrization. The chance of success is less the later this agency is employed. In those more favourable cases in which voluntary power has returned, the muscles often continue for a long time weak and atrophied. Then a short period of faradization with a current of medium power will often quickly develop them and render their nutrition active. Fig. 56 is an example of paralysis of four years' date, almost completely destroying the muscles of the shoulder and arm. Each muscle was faradized with a tolerably intense current, and this treatment was regularly followed for more than two years. Progressive improvement was the result, and the deltoid was gradually developed. Fig. 57 is another example of atrophy of the shoulder muscles, and consequent subluxation of the head of the humerus. Fig. 58 shows a shoulder whose muscles had been equally atrophied with fig. 57, but they are now developed by faradization. The relief of the anterior part of the deltoid is manifest, and the well rounded shoulder forms a striking contrast with figs. 56 and 57. With muscular nutrition

Infantile Paralysis.

voluntary movement also returned. In such cases a satisfactory result can only be expected after long perseverance in the treatment, and even when the absence of visible muscle leads us to fear that its tissue is entirely degenerated, we may hope that a few sound fibres yet remain about which, and from which, it may be possible to develop others, and by their union to form muscular fasciculi, parts of muscles and even entire muscles. But it must be borne in mind that such a result can only be obtained by very long treatment, and it will be useless to begin unless there is the determination to continue the treatment for a year or even two.

Fig. 56.

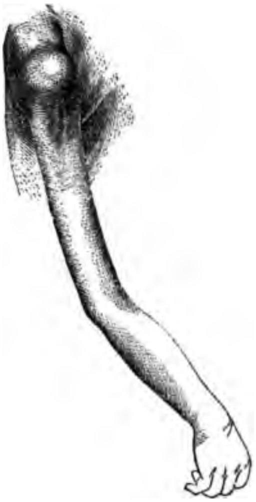


Paralysis of muscles of Shoulder and Arm.

Infantile Paralysis.

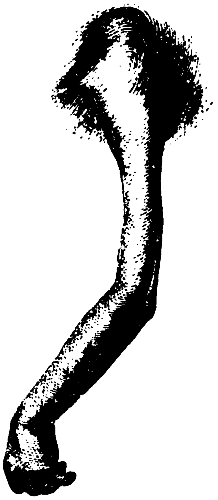
Fig. 59 is from a striking photograph of atrophic paralysis of the hand. Fig. 60 exhibits the same hand after treatment by faradization.

Fig. 57.



Atrophy of muscles of Shoulder.

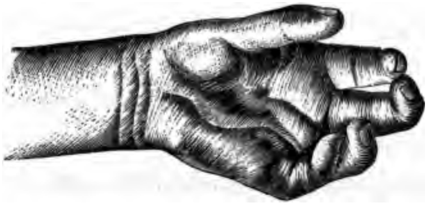
Fig. 58.



Muscles developed by Faradization.

In common with the degeneration of the muscles, the bones also undergo an arrest of development, adding still more to the deformity. Duchenne has found faradization considerably lessen this shortening, and

Fig. 59.

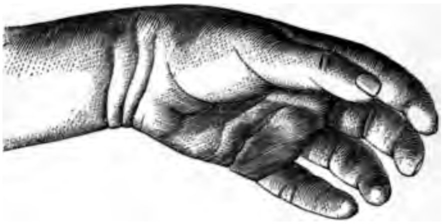


Atrophic Paralysis of Hand.

Infantile Paralysis.

even redevelop them. He does not speak favourably of treatment by the interrupted voltaic current. Hesitating, as I cannot but do, to express an opinion adverse to the conclusions of so distinguished an authority, I am yet convinced that all those cases in *which irritability to this current is increased*, will make better progress under it than under faradization. As a rule, I should advise such cases to be treated at first with the interrupted voltaic current, and subsequently with the use of the two kinds of currents alternately. In Duchenne's hands the application of voltaism to infants has been attended with unbearable pain. I have not found it so, if only from ten to twenty-five cells are used, and more are hardly ever required. As soon as there is a return of reaction to faradization, faradization should be solely used. In addition to electrization the paralysed limbs should be immersed in water, as hot as can be borne, for a quarter of an hour twice a day, and should afterwards be well rubbed and shampooed. Infantile paralysis is almost always a

FIG. 60.



The same, after Treatment.

Infantile Paralysis.

tedious disease, and treatment must be continued for weeks, months, or even years. Parents are apt to bring such children to you with the expectation that after every other remedy has failed, electricity is going to work miracles. The reader is advised always to explain to them the probable length of treatment required, and to decline to have anything to do with the case for a few applications only. Dr. Radcliffe truly says, in his article on this disease in Reynolds's "System of Medicine," that "if the paralysed muscles retain their electro-contractility and sensibility, and so show that they have not passed into that state of fatty degeneration into which they always tend to pass eventually, there appears to be scarcely any limit to the time in which improvement and even complete recovery is possible;" and, further on, he adds, "that in all cases the electrical and gymnastic parts of the treatment are of primary rather than of merely secondary importance, I am every day more and more convinced, because every day I meet with instances of muscles which I should once have looked upon as hopelessly paralysed, being resuscitated by these means."

When *any* amount of voluntary power has been restored by electricity, it is most important that the child should be encouraged to use the limb, and practise various movements. In every variety of paralysis, as well in adults as in children, it ought

Paralysis.

always to be remembered that after protracted paralysis the muscles are likely to have forgotten their movements, and, like a child learning to walk, they want instruction. Every paralytic should devote a quarter of an hour twice a day, *even when loss of power is well nigh complete,* to *trying* to make the muscles obey the will. This is a matter that in general is far too much neglected.

Hemiplegia.

The subject of electrization in hemiplegia from cerebral disease, and the proper moment for its application must be carefully considered. It is never advisable until some months, four to six, after the attack, and then the question arises whether the persistence of the hemiplegia arises from the muscles having lost their old aptitude of response to the influence of the will, or from the cicatrix or cyst exercising positive pressure upon the cerebral tissue, or from loss of cerebral substance. (I refer to hemiplegia from brain disease, hæmorrhage, or softening.) When there is no rigidity and the muscles are lax, faradization is advisable, for usually the brain lesion is then repaired, and the paralysis is peripheric, and localized in the muscles. Where there is much rigidity, especially with increased reflex action, irritative lesion still persists, and faradization will do no good, and may do harm. But there are many intermediate degrees of lesion that may be benefited; and in almost all cases in which after a spontaneous

Paralysis. Hemiplegia.

partial return of voluntary movement, the patient suddenly stops short, and for many weeks or months makes no further progress, faradization comes in, and the immediate good that it will often do is surprising. Half a dozen applications give a fillip to the muscles, and more improvement is often effected in a week than in the preceding year. The improvement is generally sudden. The "late rigidity" of hemiplegia may be largely relieved by electrization. Such a case was recently sent to me for electrical treatment, by Mr. Willett, from St. Bartholomew's Hospital. As the result of an accident there had been compound fracture of the right parietal bone, loss of brain substance and immediate left hemiplegia. The patient was trephined, and after some months' treatment there was considerable return of voluntary power, but with cicatrization there supervened extreme rigidity of the flexor muscles of the left hand, the fingers of which were so tightly contracted that the hands could with difficulty be forced open, and immediately after being opened they reclosed involuntarily. There was also rigidity of the biceps, the forearm being carried semiflexed with inability to further extend it. The continuous voltaic current was localized in the rigid muscles for five minutes, and their antagonists energetically faradized for a second five minutes, three times a week for three months, with the result that at the end of that period the patient could quite straighten his arm,

"Late Rigidity."

Paralysis. "Late Rigidity."

and fully extend the fingers to a level with the back of the hand. In such cases, or whenever a powerful current with little pain is required, Duchenne's pedal rheotome (Y, fig. 11, page 21) is of great value. By it the current may be interrupted three or four times in a minute, instead of three or four times in a second, which is about the slowest rate of any interrupting hammer of a faradic instrument; and a current sufficiently powerful to penetrate thick muscles may be applied in circumstances under which a very much weaker current rapidly interrupted would give equal pain, and be strong enough only to act upon the superficial muscular fibres.* I need hardly remind the reader that always in these electrizations every part of each muscle must be equally excited, as described at page 55, and that it is never necessary to use painful excitation in any paralysis except when the muscles have lost their sensibility, or when as in atrophy, their nutrition is impaired. During faradization I have never had the misfortune to witness the occurrence of a second apoplectic seizure, and I am confident that faradization skilfully administered has never produced one; but it is wise to remember that all such patients are predisposed to a second attack which, if it occurs, is very likely to be attributed to the electrization. **Paralysis**

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* My friend Dr. Gowers has improved upon Duchenne's rheotome by having it so constructed that a slight twist of the foot will fix it immovable, and so maintain the current when required without interruption while the foot is removed, which cannot be done with Duchenne's. He has also arranged a pedal commutator of the poles by which the direction of the current may be instantly changed by pressure with the foot. Dr. Gowers' Pedal Commutator can be obtained from Weiss and Co., 62, Strand. It consists of three buttons arranged in a line upon a wooden slab six inches by four. The central button is the rheotome, and the outer buttons the commutators.

Paraplegia. In paraplegia from myelitis electrization cannot be, any more than in hemiplegia, had recourse to during the period of active mischief; its use can but be to preserve the nutrition of the muscles cut off from central innervation, and this should not be attempted while active mischief exists. In the persisting localized paralysis following upon myelitis electrization is of the greatest service.* The difficulty is to determine the proper moment for the application of this agent. The paralysed muscles should be examined at intervals with the faradic and interrupted voltaic currents, and when it shall have been determined that electrization may be used, one or the other form of current, and at a later period perhaps both currents, should be used according to the suggestions already given. I should be disposed also to charge the patient with

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* Brown-Séquard's experiments prove that after traumatic lesion the cord may be perfectly restored. He divided the cord of a pigeon about the level of the fifth or sixth dorsal vertebra. There was a slight return of power in three months and almost complete recovery in fifteen. The animal was then killed, and on examination, it was found, in the author's words, that "*les cicatrices des plaies anciennes de la moëlle épinière renfermaient des fibres nerveuses ayant tout à fait l'aspect normal, et se continuent avec les fibres des parties intactes de la moëlle.*" Identical results were obtained in several cases. *Brown-Séquard, Comptes Rendus de la Société de Biologie.—Juin,* 1851.

Paralysis. Paraplegia.

positive voltaic electricity after the method of Dr. Radcliffe, or the constant current may be applied in continuity to the spine, or one electrode may be held stationary and the other moved up and down the spinal column, as advocated by Benedikt. These methods are worthy of a trial also in those cases in which, although the cause of the paraplegia may have been removed, the cord itself would appear to have lost more or less of its excitability.

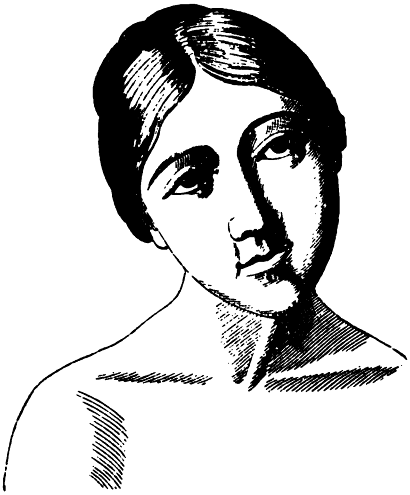
Wasting Palsy

In that most distressing and intractable disease Cruveilhier's atrophy or wasting palsy a combination of localized muscular faradization with Dr. Radcliffe's "positive charge" should always be given a fair trial, the more so as medication is well-nigh useless. In some cases in which I have pursued this plan of treatment there has followed a filling out of the wasted muscles and an arrest of the disease. Localize faradization in the wasted muscles, and vary this treatment on alternate days by the "positive charge." If the disease is in the upper extremities, each hand may be immersed in a separate vessel of brine with one pole, and a "ground wire" carried to a chandelier from that containing the negative; or if the lower limbs are affected they may be placed in foot pails in the same manner, or one arm and one leg according to the localization of the disease. The patient and the battery must be both insulated, the charge as strong as can be borne without discomfort, and the length of time about twenty minutes. Faradize only those muscles that respond to the excitation. To faradize others is useless, for in this disease as long as any muscular tissue is left, response to faradism remains and its abolition proves complete degeneration. No electrization can then recall the muscles to life.

Tremor.

In all cases in which tremor or spasm is a prominent symptom Dr. Radcliffe's positive charge holds out promise of the happiest result. If during the time of the charge the tremor ceases the prognosis is the more favourable. From this treatment I have had good results in several cases of spasmodic wry-neck (torticollis) from contraction of the sterno-

FIG. 61.

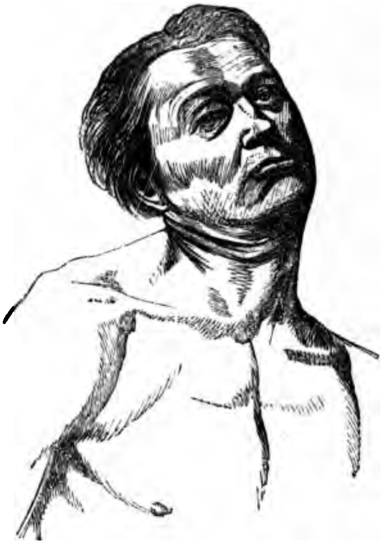


Torticollis.

mastoid, splenius or clavicular portion of the trapezius, or of some deeper seated muscles. In these cases it is always advisable to combine with the charge energetic faradization of the antagonists of the contracting muscles ; and the same treatment may be followed with advantage in writer's cramp and

Writer's Cramp.

FIG. 62.



Contraction of Splenius.

analogous affections, especially when conjoined with appropriate gymnastic exercises of the affected muscles alternating with periods of perfect rest to them.

Torticollis.

Fig. 61 is an instance of torticollis, of thirteen months' duration. The patient was a girl. The head was inclined towards the right shoulder, and slightly towards the scapula. She could bend the head but very little forwards, and not at all to the right, and trying to do so caused acute pain in the back of the neck near the upper attachment of the right trapezius, whose rigid tendon could be seen and its resistance felt. The prominence of the sternomastoid could be artificially caused on the right side by faradization. Localized faradization of the clavicular portion of the trapezius of the opposite side resulted in a perfect cure.

Torticollis.

Contraction of Splenius.

Fig. 62 represents a case of contraction of the splenius. The symptoms were inclination of the head backwards and towards the contracted side, with swelling of the splenius sensible to the touch. Faradization of the antagonist splenius entirely removed the deformity.

Tonic Contractions.

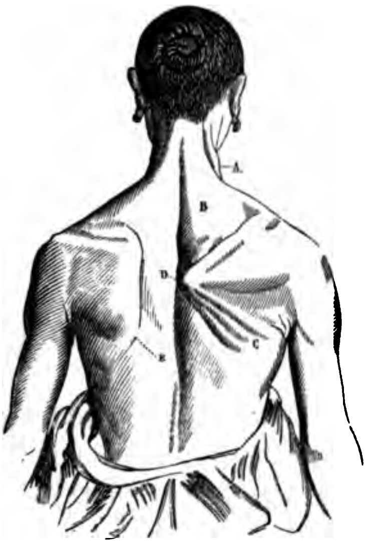
In long-standing cases also of tonic contractions of muscles, such as sometimes accompany muscular rheumatism, excitation of the antagonists of the affected muscles proves highly successful. Duchenne reports numerous cases. In one of these, in which contraction of the rhomboid had existed for some years, faradization of the radiating fibres of the serratus magnus, its antagonist, was quite successful. Fig. 63 represents the case before, and fig. 64 after treatment. The patient was a girl thirteen years of age. The affection commenced with pain in the centre and right-hand side of the neck, increased on pressure or movement of the

Contraction of Rhomboid.

Contraction of Rhomboid.

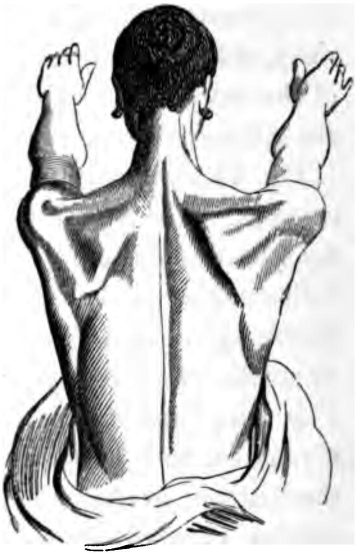
head. This was followed by deformity of the muscles, which increased for four years. When Duchenne first saw her, her condition was as follows. The arms hanging at rest, the inferior angle (D, fig. 63) of the right scapula was drawn up until it was

Fig. 63. *



Before Treatment.

Fig. 64.



After Treatment.

almost on a level with the external angle and caused a marked projection. To bring it down into its normal position required the exertion of considerable strength, and the moment it was released it sprang back with an audible crack. Beneath the

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* A. The levator scapulæ. B. The retracted rhomboid. C. Fibres of the serratus magnus. D. Abnormal position of the inferior angle of the scapula. E. The inferior angle on the healthy side.

Contraction of Rhomboid.

spinal border of the scapula, which occupied an oblique position from within outwards, was a considerable swelling, B, the retracted rhomboid. A second swelling over the right shoulder was caused by the internal angle of the scapula, which could be distinctly felt under the skin, and to the prominence, A, of the levator scapulæ. Finally the head was slightly bowed to the right, and an attempt to incline it to the left caused pain. Duchenne produced during the passage of the current a precisely analogous deformity in a healthy person by faradization of the rhomboid and levator anguli scapulæ. To bring down the inferior angle, D, to the level of that of the sound side, the radiating fasciculi of the serratus magnus were faradized; the scapula resumed its normal position, and the swelling, B, disappeared. The sitting lasted ten minutes, but at the end of it the deformity returned. This treatment carried out three times a week for a month produced not the slightest improvement, but to avoid pain to the child, the current had been interrupted only once or twice in a second. A very quickly interrupted current, causing great pain was now used. In four or five minutes there was a sensible improvement; the inferior angle resumed its abnormal position less readily, and remained slightly lower than before. The improvement was maintained the next day, and in a few more applications all deformity disappeared, and the bone retook its natural position.

The above case is an example of the occasional necessity of very painful electrization.

Reflex Contraction.

There is a sort of reflex contraction which sometimes follows upon contusion of an articulation, as in the wrist from falls upon the back or palm of the hand, and which usually appears after the local inflammation has subsided, affects a number of the muscles about the joint, and at length may extend to other joints of the limb. The pain, limited at first to the muscles first affected, soon extends to others, to the nerve trunks, and finally to their origin in the brachial plexus. Here again painful faradization of the antagonists of the painful muscles has, in Duchenne's hands, been most successful.

Hysterical Paralysis.

Hysterical paralysis, whether accompanied by anæsthesia or hyperæsthesia, will frequently be removed by cutaneous faradization with the wire brush, or by localized muscular faradization. In most cases while contractility is intact, sensibility is abolished or diminished (a valuable diagnostic sign of hysterical from cerebral hemiplegia). If electrization proves of benefit, it will usually do so in two or three sittings, and it is as a rule useless, to continue beyond half-a-dozen if there is then no improvement. The treatment must be localized in each of the affected organs, and continued some time after return of movement, so as to fix, so to say, the cure. In hysterical contractions, as of the fingers, on account of the extreme excitability

Hysterical Paralysis.

of the cord, faradism may do harm. Dr. Radcliffe's positive charge should be used. In those cases in which there is excessive localized sensitiveness, which is not lessened either by cutaneous faradization or voltaization by sparks, I have occasionally found benefit from the constant current, one electrode on the painful spot, and the other as near as possible to the nerve origin, with as powerful a current as the patient will submit to. I refer only to hysterical hyperæsthesia, not to neuralgia.

Local Paralysis.

In all cases of local paralysis which are dependent upon blood poisoning, such as mercurial and lead palsy, electrization is never to be neglected. In most cases, even those which have resisted the most energetic prior treatment, a combination of the interrupted voltaic current and faradization, alternately localized in the affected muscles, will triumph over the disease. The current must be sufficiently powerful to cause pain. Such cases are tedious, requiring from twenty to fifty sittings.

In the local or partial paralysis of muscles, which not uncommonly results from exposure to cold, the farado-muscular contractility is usually intact. Rheumatic paralysis of the radial nerve may be cited as an example. This is liable to be confounded with lead palsy. In both diseases the same muscles are affected, the extensors of the hand and fingers, the supinator longus, and all the muscles supplied by the radial nerve, but in lead palsy farado-contractility and sensibility are diminished or abolished, while in paralysis from cold they are normal, and the sensibility may be increased. The only exception to this rule is in facial paralysis from cold, where the farado-contractility is diminished, or absent, and this diminution may perhaps be explained by the fact of the facial nerve traversing a bony canal (the acqueductus Fallopii), where, if the nerve swells, it is practically compressed. This paralysis may almost always, even after it has been stationary for many months, be cured by voltaization and faradization, but much more quickly where the farado-contractility remains. The muscles must be treated by that current to which they respond, but with faradization it is especially necessary on the face that the *direct* should be preferred to the *indirect* application. In almost all cases the muscles recover unequally; reaction returns in one before in another, *although supplied by the same nerve.* The excitation must then be localized more in the backward muscles, or a deformity may result. In the most favourable cases an unnatural expression of countenance will generally persist for a long time, from the non-recovery by the muscles of their perfect tone, that quality which imprints upon each face its characteristic features, and which has been called the "gymnast of the soul." Few patients will submit long enough to electrical treatment to

Facial Palsy.

Facial Palsy.

obtain perfect regularity upon both sides of the face. Any spasm or fibrillation following faradization, or any artificial excitation, is a warning of threatening tonic contractions of the muscles, and faradization must be at once discontinued, or deformity will result. Such cases make good progress under Dr. Radcliffe's positive charge, applied daily. I have now under treatment a case of right facial paralysis of twenty-three years' standing. Before the patient was placed under my care there had been, from energetic faradization, considerable improvement, but incessant muscular fibrillation remained. Under daily treatment with this positive charge the fibrillation has disappeared, and there is also much increase of power in the paralysed muscles.

Paralysis of Muscles of Eye.

There are several other strictly local palsies that may be successfully treated by electrization, as for instance, paralysis of the muscles of the eye, when the disease is not the result of central lesion. One pole must be placed over the facial nerve below the ear, and the other applied to the closed eyelid for about twenty seconds, the entire application lasting about five minutes.

In such cases Mr. R. Brudenell Carter has recommended tenotomy of the contracted, and faradization of the paralysed, muscle by direct application to the conjunctiva. This is an exquisitely painful application, and I have found few patients

Paralysis of Muscles of Eye.

who will submit to it, while in the majority of cases the above far less severe procedure is equally efficacious. Similar treatment is required in mydriasis or dilated pupil from paralysis of the iris, a very troublesome affection on account of its interference with the sight by admitting too much light to the retina. If, however, direct applications be made to the conjunctiva, see that the margins of the eyelids do not touch the stem of the rheophore, or severe spasm will result: to avoid this pinch up the skin of the eyebrow between the thumb and finger, and so retain it during the operation.

Amaurosis.

Certain amauroses depending upon torpidity of the optic nerve may be removed or greatly lessened by a daily application of the interrupted voltaic current, the special action of which upon the retina has been already set forth. The directions above given for faradism apply equally to voltaization: but as these amauroses are symptomatic of essentially different conditions, the ophthalmoscope must always be first employed for their diagnosis.

Deafness.

Faradization is often of signal service in nervous deafness, that variety of deafness in which no organic lesion can be discovered by the aurist, and which is frequently extremely intractable to medical treatment. Duchenne quotes cases that had existed from two to twenty years, and in which a perfect and permanent cure resulted after from fifteen to thirty applications made as described at page 77. Commence with the lowest power of the

Deafness.

primary coil, and with about two intermissions in each second. Never make the application *without using the pedal rheotome,* and increase the power gradually until a distinct sensation a little short of pain is felt either in the meatus itself or in the tongue. Be careful that the conducting wire of the rheophore does not project beyond its insulating cylinder and touch the mucous membrane of the meatus, or acute pain will be caused. Faradize on alternate days for about five minutes. Should the least giddiness occur, discontinue instantly and lower the strength of the current. In certain cases of congenital deaf-mutism, not depending upon any anatomical lesion, the trial of similar treatment is advisable. Hysterical deafness, even of many months duration, is usually quickly removed in from two to six applications.

Glosso-labio-laryngeal Paralysis.

In *glosso-labio laryngeal paralysis* faradization of the tongue and of the muscles of the pharynx will improve for a time the articulation of words and the deglutition. One pole is to be applied to the nape of the neck, and the other in succession to all parts of the tongue and lips that are wasted, and externally, with a powerful current, to affect the pharynx.

Locomotor Ataxy.

In *locomotor ataxy* faradization, while powerless to cure, is one of the best palliatives. By its application the diplopia, a common symptom in the first stage of the disease, is for the most part removed for a time, to the great comfort of the patient.

The distressing muscular pains will often diminish or even disappear under cutaneous faradization, as also the muscular and cutaneous anæsthesia which greatly add to the troubles of co-ordination, and upon the diminution of which a marked improvement in locomotion generally results. At an early period of the disease the constant voltaic current to the spine—both poles stationary—may be tried.

Muscular Rheumatism.

The pains of muscular rheumatism are almost invariably removed or mitigated by cutaneous faradization, and so rapidly as in many cases to appear marvellous. In cases that had resisted all other treatment, an instantaneous cure has resulted, and sufferers whose pain has for a long time obliged them to keep the arm immovable have been able directly after the faradization to execute any movement with ease. With these rheumatic patients it is especially of importance that the current should be strictly limited to the skin, carefully dried and powdered, and should *produce no muscular contraction*, or the suffering will be aggravated instead of relieved. Begin with a current readily bearable on your own hand, and increase afterwards. The above remarks are applicable to all varieties of muscular rheumatism, but not to arthritic disease.

Artificial Respiration.

In all cases of chloroform narcosis faradization of the phrenic nerves, as detailed at page 60, is of the first importance, but if unsuccessful, recourse should, without loss of time, be had to cutaneous faradization

Artificial Respiration.

of the precordial region. The instrument being at its full power and with rapid intermissions, the wire brush is to be brushed over the left nipple, and a disk conductor connected with the other pole moved about over the apex of the heart. Duchenne speaks highly of this precordial cutaneous excitation, (which he believes to react upon those points of the nervous centres which govern the innervation of the breathing and of the heart's action,) in disorders of the cardiac circulation symptomatic of a paralytic condition of the vagus, causing syncope, which is sometimes fatal. He quotes an interesting case of diphtheritic poisoning of the vagus; and consequent extreme rapidity, smallness, and irregularity of the pulse, with syncope. Diffusible stimulants failed to give relief. The symptoms were removed as if from enchantment by cutaneous faradization, and if the conductors were moved to other parts of the chest, the patient experienced no benefit, and quickly pointed to the region to which the electricity should be applied. There are also other functional disorders of innervation which are much ameliorated by similar treatment—particularly a kind of apnœa, a neurosis characterized by absence of the *besoin de respirer*, and which for a certain time renders the respiratory movements infrequent and even suspends them.

Functional Disorders of Innervation.

Diphtheritic Paralysis.

Duchenne quotes other cases of successful treatment of diphtheritic paralysis by faradization. In one the patient appeared to have contracted membranous

Diphtheritic Paralysis.

angina by kissing the mouth of one of his children who died from the disease. After having passed through the period of the formation of false membranes, which put his life in danger by obstructing the bronchi, and when making progress towards convalescence, he was attacked by paralytic symptoms. There was paralysis of the soft palate and pharynx, diplopia, and slight hemiplegia of the fifth, seventh, hypoglossal, and inferior laryngeal nerves. Suddenly on the twenty-eighth day, the intrinsic expiratory muscles became paralysed, and at the same time there was formed a considerable quantity of mucus, which obstructing the bronchi, and not being expelled, threatened to produce asphyxia. Electro-cutaneous excitation of the posterior region of the thorax rapidly re-established the respiratory power and procured the immediate expulsion of the bronchial mucus, but it required to be continued for several days in order completely to overcome the paralysis of the lung.

In another instance, a little girl four months old, who had suffered from diarrhœa for several days became the subject of a rather large ulceration in the neighbourhood of the umbilicus. Some days later she was attacked by general paralysis, which continued for forty-eight hours, and was followed by complete aphonia, with extreme difficulty of respiration and deglutition. Every attempt at sucking brought on cough and choking, Diphtheritic Paralysis.

and there were also symptoms of paralysis of the diaphragm. Faradization of the phrenic nerves was entirely successful in establishing normal respiration. After faradization of the soft palate, the pharynx, and the anterior surface of the neck at the laryngeal level, the infant sucked better and its voice improved. It was completely cured by a few applications.

Difficulty of Micturition.

Difficulty of micturition, may in many paraplegic cases be largely relieved by faradization. It is not always symptomatic of paralysis of the bladder, but may be the result of paralysis of the abdominal muscles, and be removed by their faradization. Failing this, the rectal rheophore should be introduced, as described at page 72, and a well wetted sponge connected with the second pole promenaded over the hypogastric or lumbosacral region; or the double vesical rheophore may be employed. The continuous voltaic current will often relieve vesical spasm, and has been successfully employed in painful spasmodic contraction of the bladder upon a calculus. Lesser degrees of spasm will often give way to cutaneous faradization of the perineum or hypogastric region. Anæsthesia of the bladder sometimes exists independently of any paralysis. The patient feels no desire to micturate, the bladder fills and if not emptied at regular intervals ends by becoming paralysed from the constant distension. Internal faradization with the double vesical rheophore is superior to any other treatment.

Impotence.

Impotence is not unfrequently found to be accompanied by anæsthesia of the genitals, and to be removed by cutaneous faradization. In those cases in which it is due to seminal emissions, and prior treatment has been of no avail faradization should be given a trial. Introduce the urethral rheophore to the verumontanum, and apply a second rheophore (a well-wetted sponge in a cylinder) to the perineum. Use a low power, and with the pedal rheotome regulate the intermissions at about the rate of two to a second. When the emissions are better pass a mild and slowly intermitting current through the testicles, applying a well-wetted conductor on each side of them.

Constipation of Paraplegia.

Obstinate paraplegic constipation is often relieved by faradization of the abdominal muscles. When it results from paralysis of the rectum, act directly upon it as described at page 72. In intussusception introduce the rectal rheophore and apply about once in a second (regulated by the pedal rheotome) an intense faradic current upon each point of the abdominal walls. Several successful cases that had resisted all prior treatment are on record. Prolapsus ani from atony of the sphincter may not unfrequently be removed by faradization.

Electrolysis.

Electrolysis.—In certain cases in which a tumour rapidly increasing may threaten life, and where from its position, or for other reasons, a surgical operation is inadmissible, the catalytic or resorbent action of the continuous voltaic current may be of

Electrolysis.

benefit. In preference to the insertion of needles, mould a very thin sheet of copper, hardly thicker than paper, to the entire surface of the tumour. Cover this copper with a flannel and fix it by a binding screw to the conductor from the negative pole of the battery. Before use, soak the flannel well in a saturated solution of salt in water, and when applied to the tumour, place the positive pole with a well-wetted sponge as near as possible to it, and allow a current as strong as the patient can bear without pain to pass for from twenty minutes to an hour daily, or every second day. The same treatment is occasionally useful in ganglionic tumours and in chronic articular affections with nodosities, which have not been benefited by prior treatment. If needles are used, introduce two or three, or even four, of steel gilt, into the most prominent part of the tumour to a depth of two or three inches, and connect them with the negative pole of about ten cells. Apply the positive pole as already directed.

Contra-indications to the use of Electricity.

Contra-indications to the use of Electricity.—In actual softening of brain or spinal cord; in active or severe inflammations or congestions, whether central or peripheral; in great exaltation of reflex action, after recent paralytic seizures, and in those conditions generally in which active medication is contra-indicated, electricity, except as a mild continuous voltaic current, should not be employed.

Concluding Remarks.

In the foregoing pages I have endeavoured—assuredly not to exhaust my subject—but, eschewing debatable ground, to indicate the prominent landmarks in the wide and unexhausted field of electro-therapeutics. My object will have been answered if I have succeeded in clearly describing the different modes of applying electricity, and the apparatus by which the application is best made; also in specifying those cases in which the use of some one or other of the different varieties of electricity is imperatively demanded; and those cases again where—other remedies having been tried and failed—we may hopefully resort to this agent, and in which it were surely a neglect of duty to let the disease run on without giving the patient the benefit of its thorough trial.

In conclusion I would state that the medical practitioner who prescribes electricity, should either administer it himself, or cause it to be administered by a skilled operator. The experience of the National Hospital for the Paralysed and Epileptic, and my own experience in private practice, show conclusively that when patients themselves apply electricity, the result has been very unsatisfactory. The most explicit directions will often be misunderstood, or fail in being correctly carried out, the treatment getting undeserved discredit. The rule of practice here laid down is particularly applicable to the localized application of electricity.

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